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New or peculiar aquatic fungi. 4. Rhipidium, Sapromyces, and Araiospora, nov. gen.

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WITH PLATES XXI–XXIII.

Of the numerous aquatic forms the discovery of which we owe to the researches of Cornu, the four species which he placed in the genus Rhipidium[1] are among the most interesting from their striking peculiarities as well as from the fact that, as far as the writer is aware, they have been observed by no other botanist. It is true that Cornu regarded the Naegelia of Reinsch as identical with one of his species of Rhipidium; but, as has been mentioned in a previous note,[2] it seems quite unlikely that this is the case. Owing to the fact that Cornu's account, which was avowedly a preliminary one, has not been supplemented by any details or figures, with the exception of certain illustrations in Van Tieghem's Traité de Botanique, it is impossible to form any very accurate idea of the essential differences which separate the species; and for the same reason the true limitations of the genus itself are by no means clear. The difficulty is further increased from the fact that the figures just mentioned do not correspond to the description of the species represented in one very important respect, so that in view of this uncertainty both as to generic and specific characters, the writer

[1] Cornu, Monographie des Saprolégniées. Ann. d. Sci. Nat. Bot. V. **15:** 15 ff. 1872. Also Bull. Soc. Bot. de France **18:** 58. 1871.

[2] Bot. Gazette **19:** 50. 1894.

has felt obliged not only to describe under a new name the common American species, but to modify the limitations of the genus as described by Cornu.

In general terms *Rhipidium* Cornu may be said to be characterized as possessing a highly developed basal cell, attached to the substratum by rhizoids, which gives rise terminally to a number of filaments successively constricted and bearing sexual and non-sexual reproductive organs. The sexual organs consist of oogonia in which single oospores are produced as a result of fertilization by an antheridium, peculiar from the fact that it always penetrates the oogonium at a definite point on the surface of the latter. The sporangia are more or less oval in form and emit the zoospores in a cylindrical mass surrounded by a thin membrane which ruptures almost immediately, allowing them to escape.

Such in general are the characters of the genus as originally described; and in regard to the species, a comparison of the scattered references which one finds in the "Monograph" affords the following information.

Rhipidium interruptum, as appears from the figures and description of Cornu, has oval sporangia, the filaments being characterized by the presence of numerous constrictions and sympodially (not otherwise) branched below the successively formed terminal sporangia; the segments cylindrical, short, six to eight times as long as broad. The oogonia are spherical and correspond in position to the sporangia, the oospore solitary, "étoilée" or "munie de crètes très saillantes."[3] The antheridia are heterogenous, borne at the tips of long and twisted filaments and apply themselves near the base of the oogonium,[4] although in the figure given in Van Tieghem[5] they are represented as being applied near the apex.

R. continuum is described as resembling the preceding species in all respects except that the filaments are continuous, the only constrictions present being those which separate them from the basal cell and from the reproductive organs.

R. elongatum differs from the two preceding species in that the successive segments of the filaments are clavate and very long, attaining a length sometimes of a millimeter. The surface of the oospore is, moreover, undulate, and the antherid-

[3] Cornu, Monograph l. c. pp. 15 and 103.
[4] op. cit. p. 30.
[5] Traité de Bot. 1024. *fig. 617.*

ial filament is spirally twisted below the antheridium, which applies itself to the apex of the oogonium by means of a terminal beak-like process. Whether the filaments are umbellately or otherwise branched is not mentioned.

R. spinosum, the fourth and last of the species described, is still more imperfectly known; but may be distinguished from the others by the fact that its sporangia are furnished with stout spines directed upwards and downwards, and are borne sub-umbellately at or near (?) the tips of the segments.

If one compares this fragmentary information, which, although it is perhaps sufficient to distinguish these four species from one another, is quite inadequate to afford a means of separating them from other allied forms, it becomes apparent that, although the two first, together with the American species subsequently described, are undoubtedly congeneric, the others are by no means certainly so. The characters of *R. elongatum* in particular, so far as we are informed concerning them, when compared with those of the species of Sapromyces, indicate a generic identity which can hardly be doubted. On the other hand the characters of *R. spinosum* suggest a similar identity with the generic type described below as Araiospora. To make these points more clear a brief review of the chief characters of the three genera just mentioned will be necessary.

The genus Rhipidium, if we limit it as above indicated to the three species *R. interruptum*, *R. continuum* and *R. Americanum*, is characterized by a differentiation, more extreme than in the other instances to be described, between its monstrously developed basal cell and the often very numerous filaments to which it gives rise. This basal cell is distinctly *sui generis*, and although it may be variously modified from the fact that it is often more or less regularly branched or lobed, is utterly different in character from the segments of the branches to which it gives rise. Its walls are usually greatly thickened and it is, as a rule, very abruptly expanded distally; its lower extremity being fastened to the substratum by numerous rhizoids. From the edges or from the upper surface of the expanded portion, from which they are separated by a constriction, are produced the filaments; and on the latter are borne the reproductive organs. These filaments, as in other members of the Leptomitaceæ, are characterized by a segmentation which, as we have seen, is very well marked

in *R. interruptum;* while in *R. continuum* the whole filament constitutes a single segment. In *R. Americanum*, on the other hand, we have a transitional form, in which the filament may consist of one or of several segments. The filaments themselves are in all the species apparently simple, although in reality they consist of a succession of sympodial branches which arise below each sporangium after it has formed, the further upward growth of the branch causing the sporangium, though really terminal, to assume an apparently lateral position. This type of filament is distinctly characteristic of the genus as limited above; and, although it occurs neither in Sapromyces nor in Araiospora, is identical with that which is present in the ordinary sporangiferous filaments of Apodachlya. The sporangia, as has just been mentioned, are terminal, and are typically solitary, although they may, especially in rather depauperate specimens, occur several together at the extremity of a filament. Several, however, often succeed one another at intervals on the same filament (fig. 5). The form of the sporangia, although in *R. Americanum* it shows a considerable degree of variation (figs. 7 and 15), tends, in specimens that have developed under favorable conditions, to assume the characteristic shape represented in fig. 6; and the same peculiarity is noticeable in the published figure of *R. interruptum.*

The sporangia produce a comparatively small number of rather large zoospores, which are peculiar not only from their appearance, but from the manner in which they make their escape. As the sporangium matures, a broad and conspicuous papilla is formed at its summit (fig. 7), and its wall is evidently double; for when the zoospores are ready to emerge, the outer wall splits around the base of this papilla which is then carried upwards at the extremity of the emergent mass of spores (fig. 8), remaining attached to the inner wall which also surrounds the spore mass. The latter makes its exit in the form of a cylindrical column (fig. 9) which may reach a length equal to twice that of the sporangium before the thin surrounding wall becomes ruptured, usually at the side (fig. 10), allowing the zoospores (fig. 11) to escape. This process only occurs when the plant is growing under favorable conditions, and very often the inner wall may burst at once, turning the cap to one side and allowing the spores to escape directly from the cavity of the sporangium. The zoo-

spores are biciliate, much flattened, bean-shaped, with a slight indentation on one side, near which the cilia are attached, and are composed of large refractive granules (fig. 11) which give them so characteristic an appearance that they are always recognizable at a glance when seen swimming about in company with other zoospores. This peculiar method of egress is described by Cornu as characteristic of *R. interruptum* and his figure of the zoospores of this species represents the same coarsely granular structure. The zoospores are monoplanetic and in *R. Americanum* only the first stages of germination have been observed. The figures given in the Traité de Botanique[6] illustrate their further development in *R. interruptum*, and indicate that the body of the zoospore itself gives rise directly to the expanded portion of the basal cell, the hypha of germination forming the stalk and producing the rhizoids from its apex. The spore thus develops as it were upside down.

The oogonia are formed like the sporangia, but are usually, if not invariably terminal, and are similarly distinguished from the filaments which bear them by the characteristic constriction. They are almost perfectly spherical in form and contain a single large oosphere which is not readily distinguishable from the rather abundant peripheral protoplasm until after fertilization has been accomplished. The antheridial filament in the American species, which, unlike the two European forms, is androgynous, arises immediately below the insertion of the oogonium; and is usually very short and slender (figs. 13 and 14), seldom, if ever, exceeding the length represented in fig. 12. The antheridium is rather small and rounded, though abruptly distinguished, and applies itself close to the base of the oogonium, the wall of which it perforates without indentation. The two European forms differ not only from the fact that they are heterogynous, but on account of the much greater development of the antheridial branches which are said to be "fort allongés et volubiles."[7] The point at which the antheridium applies itself to the oogonium in these species, although, as has been already mentioned, it is represented as towards the summit in the figure given in the Traité de Botanique (*fig. 617, 1a*), may be assumed to be at the base, as in *R. Americanum*, in accordance

[6]Traité de Botanique 1024. *fig. 617. 2.*
[7]Cornu, Monograph 28.

with the statement on p. 30 of the Monograph: "le point ou se fixe l'anthéridie semble assez constant: c'est vers la base chez les *R. continuum* et *interruptum*."

As the oospore matures the peripheral protoplasm begins to contract around it producing an undulate outline, and as it hardens in forming the exospore, the contained oospore follows its outlines, becoming later quite spherical through the deposition of its proper wall. The undulate outline assumed by the peripheral protoplasm seems to be due, in part at least, to the fact that it adheres to the inner wall of the oogonium, and when it begins to shrink away from the latter, the adherent areas form the "crests" characteristic of the exospore after it has become entirely freed from this attachment. Cornu appears to lay great stress on the alleged fact that the oosphere is itself originally undulate, and that this contour is reproduced in the mature spore. This, however, does not seem to be the case in the American form; the oosphere, when first distinguishable, being evenly spherical. The mature oospore is very thick walled and colorless in the species. Its germination has not been observed.

Such are the characters which seem to the writer to distinguish the genus Rhipidium in its restricted sense. Turning now for a moment to the genus Sapromyces, a more detailed description of which may be found in the paper previously cited, it will be seen that in general habit it differs from Rhipidium from the fact that, although the whole plant arises from a single cell attached by rhizoids to the substratum (fig. 16), this cell is undifferentiated and similar, except at its base, to the segments of the filaments; although its wall is often considerably thickened. In comparing the type of branching also, it is evident that it is fundamentally different, the whole plant being a several times compounded umbel, as regards the origin of the branches as well as that of the reproductive organs. The sporangia are characteristically elongate in form and the oogonia are definitely piriform and subject to external encrustation. The two known species including that subsequently described are in the one case androgynous, in the other heterogynous; the antheridial filament in both cases being peculiar from the fact that it becomes spirally twisted below the curved, oblong to cylindrical antheridium; which is also peculiar in that it applies itself to the oogonium near the apex of the latter, which it perforates as

the result of a definite pressure by which the wall becomes distinctly indented. The species previously described (*S. Reinschii*) has been observed by the writer in great abundance and in perfect condition since the publication of the note above mentioned, and in specimens growing under favorable conditions the emission of the zoospores has been seen to be similar to that of Rhipidium except that the membrane surrounding the emerging spore mass is ruptured almost immediately, so that all but a small number of the spores escape in the usual way through the open mouth of the sporangium. In this genus the zoospores are like those of the Saprolegniæ in general appearance, and are quite unlike those which have just been described as occurring in Rhipidium.

If we compare these characters with what few data are available concerning *Rhipidium elongatum* it is apparent that, although we know nothing as to its type of branching, it strikingly resembles the species of Sapromyces in other essential points. Its antheridial branch "présente presque invariablement, au-dessous de l'anthéridie, un tour de spire, sorte de boucle incomplétement formée. Ce fait ne se présente que dans cette espèce, et il est très constant."[8] And further, "Dans le *Rhipidium elongatum* l'anthéridie a une forme spéciale; elle est oblongue, courbe, et porte à son extrémité un bec recourbé: c'est par ce bec seulement qu'elle touche à l'oogone."[9] Again "le point ou se fixe l'anthéridie semble assez constant: c'est vers le sommet chez *R. elongatum.*"[10] Lastly "le prolongement" (from the antheridium) "repousse la paroi de l'oogone, et finit par la perforer comme par suite d'une pression considerable (*Rhipidium elongatum*)."[11]

If now we examine the characters of the genus described below as Araiospora, it is apparent that it represents a transitional form between Rhipidium on the one hand and Sapromyces on the other. In general habit it resembles Rhipidium from the fact that its basal cell, unlike that of Sapromyces, is very greatly enlarged; although it is evidently a mere modification of a segment like those of the branches, which, as we have seen, is not the case in Rhipidium; while its type of branching and the form of its ordinary sporangia correspond exactly to those of Sapromyces. The oogonia, however, as

[8] Cornu, Monograph 29, note.
[9] op. cit. 31.
[10] op. cit. 30.
[11] op. cit. 40.

well as the antheridia, resemble those of Rhipidium, being spherical, without encrustation, and containing an abundant peripheral protoplasm. The antheridia, also, are exactly like those of Rhipidium, and apply themselves to the oogonium in the same position and in the same way; perforating the wall without indentation. On the other hand the genus differs from either of the other two in possessing two kinds of sporangia, one of which is identical with the type found in Sapromyces, as has been already mentioned, the other quite different in shape and furnished with numerous prominent spines; while the oospore is unique from the fact that it becomes surrounded by a cellular envelop derived from the peripheral protoplasm. The antheridial filaments, moreover, arise from special segments which are always derived from the same segment that produces the oogonia which they fertilize, and grow downward to the base of the latter, often producing one or more branches, each terminated by an antheridium.

In view of the presence of spinose sporangia borne more or less umbellately, it seems not improbable that the fungus just described may be very properly considered, at least provisionally, as generically identical with *Rhipidium spinosum;* since all we know of this species from the figures given by Cornu is that the sporangia may be oval to oblong and spinose,[12] or piriform and unarmed,[13] and that they may be sub-umbellately borne.[14]

In view of the various distinctions above enumerated, a provisional summary of the members of the Leptomitaceæ may be indicated as follows; the group being separated as a distinct family in accord with the classification adopted by Schroeter in his revision of the Phycomycetes.[15] It may be said, however, that should the family be united with any other, it must evidently be with the Pythiaceæ, if we recognize them as distinct from the Peronosporaceæ, or with the latter if we do not; since their reproductive processes coincide with those of the two last mentioned families rather than with those of the Saprolegniaceæ. It will be observed that in the following synopsis, Gonapodya has been retained in the family, where, in the writer's opinion, it may be provisionally placed

[12] op cit. *pl. 5. figs. 4* and *9.*
[13] l. c. *figs. 1* and *2.*
[14] l. c. *fig. 6.*
[15] Engler und Prantl, Naturl. Pflanzenfam. 93: 101. [Th. I. Abth. 1.]

until we have more definite information by means of which its true position may be finally determined; and also that the form described by Humphrey as *Apodachlya completa* has been omitted, in view of the fact that the non-sexual reproduction of this remarkable plant was not observed and that the nature of the sexual process described must remain a matter of great uncertainty until further observations can be made upon it.

LEPTOMITACEÆ.—Filaments segmented through the presence of successive constrictions. Oogonia containing a single oosphere surrounded by periplasm.

?GONAPODYA.—Typical segments short and broad. Sporangia pod-shaped, successively several times proliferous. Zoospores 1-ciliate (always ?).

Two species: *G. siliquaeformis* (Reinsch) Thax., Europe and America; *G. polymorpha* Thax., America.

LEPTOMITUS.—Filaments slender branched, the segments long cylindrical. Non-sexual reproduction effected by the conversion of a terminal or of several superposed segments into zoosporangia which are but slightly if at all differentiated. Oospores unknown.

One species: *L. lacteus* Ag., Europe and America.

APODACHLYA.—Filaments simple or sparingly branched. Sporangia terminal, or originally terminal, becoming apparently lateral through the sympodial branching of the segments which bear them, broadly oval or piriform and distinctly differentiated from the segments. Zoospores becoming encysted, as in Achlya, immediately after their exit from the sporangium (always ?), diplanetic. Oospores unknown.

Two species: *A. pirifera* Zopf, and *A. brachynema* (Hild.) Prings. (probably synonymous), America (Thaxter) and Europe.

RHIPIDIUM.—Plant consisting of a monstrously developed basal cell distinct in character from the segments of the numerous filaments to which it gives rise, distally expanded and either simple lobed or branched. The filaments apparently simple, but monopodially branched below the originally terminal sporangia. Zoosporangia for the most part solitary, broadly oval, the zoospores biciliate, composed wholly of coarse refractive granules, emerging from the sporangia in a cylindrical mass surrounded by a thin membrane and surmounted by the papilla of dehiscence; monoplanetic, swarm-

ing as soon as freed by the rupture of the surrounding membrane. Androgynous or heterogynous, the oogonia spherical, containing a thick-walled oospore. The antheridia small, applied to the oogonium near its base, the pollinodium perforating the wall without indenting it.

Three species: *R. interruptum* Cornu, *R. continuum* Cornu, Europe; *R. Americanum*, nov. sp. America.

Araiospora, nov. gen.—Plant consisting of a greatly enlarged basal cell attached by rhizoids from its base, and similar in character to the segments of the filaments which arise often in considerable numbers from its distal extremity. Filaments repeatedly umbellately branched, cylindrical or nearly so. Zoosporangia arising from the distal end of the segments in whorls or umbels of two kinds, the one smooth, the other differently shaped and furnished with prominent spines. Zoospores finely granular, biciliate, monoplanetic, emerging in a mass at first surrounded by a thin membrane which ruptures almost immediately. Oogonia in whorls or umbels, often associated with the zoosporangia, spherical, separated from the segment, like the zoosporangia, by a constriction. Oospores solitary, thick-walled, surrounded by a cellular envelop derived from the periplasm. Antheridial branches arising from special segments, simple or branched, the small rounded antheridia applying themselves close to the base of the oogonium.

Two species: *A. pulchra*, nov. sp., America; (?) *A. spinosa* (Cornu), Europe.

SAPROMYCES.—Plant arising from a basal cell attached by rhizoids from its base and resembling in all respects the segments of the filaments which arise in small numbers from its apex. Filaments as in Araiospora. Zoosporangia rather elongate, sub-cylindrical or broadly clavate. Zoospores as in Araiospora. Oogonia borne in whorls or umbels, piriform, often encrusted. Oospores solitary, thick-walled. Androgynous or heterogynous, the antheridial filaments arising distally from the segments, the portion immediately below the antheridium twisted on itself. Antheridium long oblong, curved, applying itself to the apex of the oogonium by means of a beak-like process by which the wall of the latter is indented before perforation.

Three species: *S. Reinschii* (Schroeter) Fritsch, America and Europe; *S. androgynus*, nov. sp., America; *S. elongatus* (Cornu), Europe.

The new species above alluded to may be characterized as follows:

Rhipidium americanum, nov. sp.—*Plate XXI, figs. 1–15.*

Basal cell very variable in form and size, attached by copious rhizoids; above more or less regularly one or more times successively dichotomously branched or lobed, the lobes or branches erect or spreading in a radiate fashion, the upper or external edges giving rise to numerous filaments from which they are distinguished by the characteristic constrictions. The filaments continuous or less frequently consisting of two or three sub-clavate segments. Sporangia typically ovoid tapering from the broad base to the bluntly rounded apex, but varying greatly in form, erect, originally terminal, one to four succeeding one another on a single filament; rarely two or three borne together terminally. Oogonia terminal, spherical, the thick-walled oospore colorless, the exospore elevated in a series of anastomosing ridges which give the spore an irregularly stellate outline. Antheridial filaments short, slender, arising immediately beneath the oogonium from the same segment; the antheridium small, rounded, applied close to the base of the oogonium. Basal cell 75 to 400μ long. Filaments 50 to 800μ long, seldom longer. Sporangia 30×20 to 86×27μ, average 50×35μ. Oogonia 40–55μ. Oospores 30–45μ in diameter.

On various decaying vegetable substances in ponds and ditches, vicinity of Cambridge, Mass., and of Kittery Point, Maine.

This species is by no means uncommon in the localities mentioned and may be obtained throughout the season from April to September, though more abundant in the late spring and early summer. It is remarkably variable and were it not that intermediate forms showed every imaginable gradation between such extremes as are represented in figs. 2 and 3 it would not be difficult to separate it into at least two species. The differences in habit as well as in the form of the sporangia seem largely due to the surroundings under which the individual has developed, and the nutritive character of the substratum on which it grows. On sour green apples for example one almost always obtains the form represented in fig. 3 and it is only in such rather depauperate specimens that I have observed the occurrence of more than one terminal sporangium. Such forms are also much more likely to pro-

duce oospores, and their zoosporangia are also subject to the greatest amount of variation both in form and in size.

Like Blastocladia, with which it is very often associated, it usually grows under rather unfavorable conditions, being surrounded by a mass of bacteria and other foreign organisms and under these circumstances it is apt to assume abnormal and irregular forms. Under such conditions the discharge of the zoospores, which is in any case a very rapid process, is usually not accomplished in the characteristic fashion above described, through the rupture of the inner membrane at the moment of dehiscence. The filaments are far more commonly unsegmented, and each sympodial branch is as a rule distinctly clavate in form, tapering towards its point of origin just below the sporangium. The oogonia in all observed instances have been terminal and as a rule are formed after the production of zoospores has begun to cease. The species is more closely allied to *R. continuum* than to *R. interruptum* and may prove identical with it when the former has been intelligibly described. The dichotomous branching of its basal cell, and its androgynous character as well as its very short antheridial filaments serve to distinguish it in the absence of further knowledge of the European form.

Araiospora pulchra, nov. sp.—*Plate XXIII, figs. 20–25.*

Basal cell variably developed, usually large, sub-cylindrical, the ramiferous extremity sub-conical, bearing often numerous (forty or less) acropleurogenous branches in a more or less distinctly umbellate fashion and separated from it by the usual constrictions. The branches composed of more or less cylindrical segments and repeatedly umbellately branched, the segments sub-cylindrical becoming more slender and usually longer as they succeed one another. Sporangia borne in whorls or umbels, sub-cylindrical or broadly clavate, and smooth; or broadly oval to piriform and furnished with large spines radiating in all directions but sometimes short and stout and confined to the distal extremity. Oogonia borne like the sporangia, the constricted portion which separates them from the segment very short. Oospore spherical, the thick wall colorless, surrounded by a single layer of more or less hexagonal peripheral cells derived from the periplasm. Basal cell 1 to 1.5^{mm} long by 50–25μ. Filaments 2750–275μ. long. Sporangia 120×30–175×35μ average 125×30μ. The spinose forms about 45–60×48–70μ the spines 10–35μ long.

Oogonia 50–60μ. Oospores 35–45μ. Peripheral cells about 7 × 10μ.

On submerged sticks in ponds and ditches, vicinity of Cambridge, Mass., and of Kittery Point, Maine.

This strikingly beautiful form is very common in the vicinity of Cambridge and may be found in abundance at almost any time during the late spring and summer. It is subject to considerable variation as regards the relative development of the basal cell and of the filaments arising from it. In some cases the latter are branched not more than once or twice as is represented in fig. 20, and in such instances the oogonia greatly outnumber the sporangia. In other cases the filaments are far more highly developed being many times successively branched, the branches growing more slender and usually longer as they are successively formed, and bearing many more zoosporangia than oogonia. It is in such individuals that the spinose sporangia most frequently occur and often greatly outnumber these of the ordinary type. The cellular envelop of the oospores remains about them after the oogonium wall has disappeared, and may be seen to consist of distinct cells. The latter are slightly inflated and the wall of the oospore follows the contour of their inner margins. The species seems to differ from the *Rhipidium spinosum* of Cornu from the different shape of its sporangia and from the fact that in the spinose form the spines are radiate and not directed "en haut ou en bas."[15] Nevertheless the species, like the Rhipidium just described, may yet prove synonymous with the European form.

Sapromyces androgynus, nov. sp.—*Plate XXII, figs. 16–19.*

Like *S. Reinschii* though somewhat smaller. The oogonia piriform, sometimes encrusted by a blackish scaly deposit. Oospores spherical, the thick colorless wall more or less modified by the presence of elevations which sometimes give it a roughly undulate outline. Antheridial branches arising close to the base of the oogonium from the same segment, a spiral twist usually present below the antheridium which applies itself to the apex of the oogonium and is similar in form to that of *S. Reinschii.* Total length 500–1000μ. Zoosporangia about 75 × 26μ. Oogonia 27–30 × 35–50μ. Oospores 20–26μ.

[15] Cornu, Monograph 15.

On submerged sticks in ponds and ditches, vicinity of Cambridge, Mass.

This species is not uncommon about Cambridge, but I have never found it growing in any very great abundance. It almost invariably produces oospores and its androgynous character is constant. It differs from *S. Reinschii* in its smaller habit, in the modification of its exospore, which, however, is not always very pronounced, and especially in the origin of its antheridial branch which in the last mentioned species always arises at a distance from the oogonium, a fact that has been established by the examination of abundant material collected about Kittery Point.

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Explanation of Plates XXI–XXIII.

Rhipidium americanum Thaxter.

Fig. 1. General habit of a more typical plant, the basal cell dichotomously thrice-lobed, the filaments showing occasional segmentation.

Fig. 2. General habit of a much branched specimen bearing both oogonia and zoosporangia.

Fig. 3. A radiately branched depauperate plant seen from above, the zoosporangia not yet mature.

Fig. 4. Lobe of a depauperate plant with mature filaments.

Fig. 5. Portion of the margin of the lobe of a basal cell showing the origin of several filaments and the whole of a single filament bearing three sporangia, two of them empty.

Fig. 6. Zoosporangium of typical form.

Fig. 7. Zoosporangium of typical form in which the zoospores and the papilla of dehiscence have been formed.

Fig. 8. Sporangium killed at the moment of dehiscence. Showing a portion of the spore mass extruded, surrounded by its envelop and terminated by the papilla of dehiscence.

Fig. 9. Dehiscent sporangium just before the rupture of the envelop surrounding the spore mass which is still terminated by the papilla of dehiscence.

Fig. 10. The same a moment later. The envelop has broken at the right allowing the zoospores to escape. The papilla of dehiscence is still attached to the envelop.

Fig. 11. Zoospores, the lowest in dorsal view.

Fig. 12. Oogonium, the periplasm in process of forming the exospore.

Fig. 13. Mature oospore in oogonium, the former seen in surface view.

Fig. 14. Mature oospore in oogonium, seen in optical section.

Fig. 15. An abnormal form of sporangium common in depauperate individuals.

Sapromyces androgynus Thaxter.

Fig. 16. General habit of a small plant bearing both oogonia and zoosporangia.

Fig. 17. Group of zoosporangia, two of them empty.

Fig. 18. Oogonium during fertilization, before the antheridial filament has become twisted.

Fig. 19. Group of two oogonia with mature oospores and twisted antheridial filaments.

Araiospora pulchra Thaxter.

Fig. 20. General habit of an oosporiferous plant of medium size.

Fig. 21. Terminal portion of a basal cell bearing several filaments with oogonia and both varieties of zoosporangia.

Fig. 22. Two sporangia, producing zoosporangia similar to the spinose type, in which the spines are absent or undeveloped.

Fig. 23. Segment bearing two typical spinose sporangia and one of the ordinary form, one of the spinose form emitting its zoospores and shown in optical section.

Fig. 24. Segment bearing an antheridial segment and two oogonia, one seen in optical section, the other represented in surface view.

Fig. 25. Portion of segment bearing an antheridial segment and an oogonium in which the peripheral cells are in process of formation.

*** NOTE. The figures are photo-lithographed from ink drawings and reduced about one-third from the originals. The approximate magnifications in diameters are as follows: Figs. 1 to 3, × 50. Figs 4, 16, 20, 21, × 90. Figs. 5, 22 to 24, × 240. Figs. 6 to 15, 17, 18, × 320. Fig. 25, × 925.

Contribution to the life-history of Sequoia sempervirens.

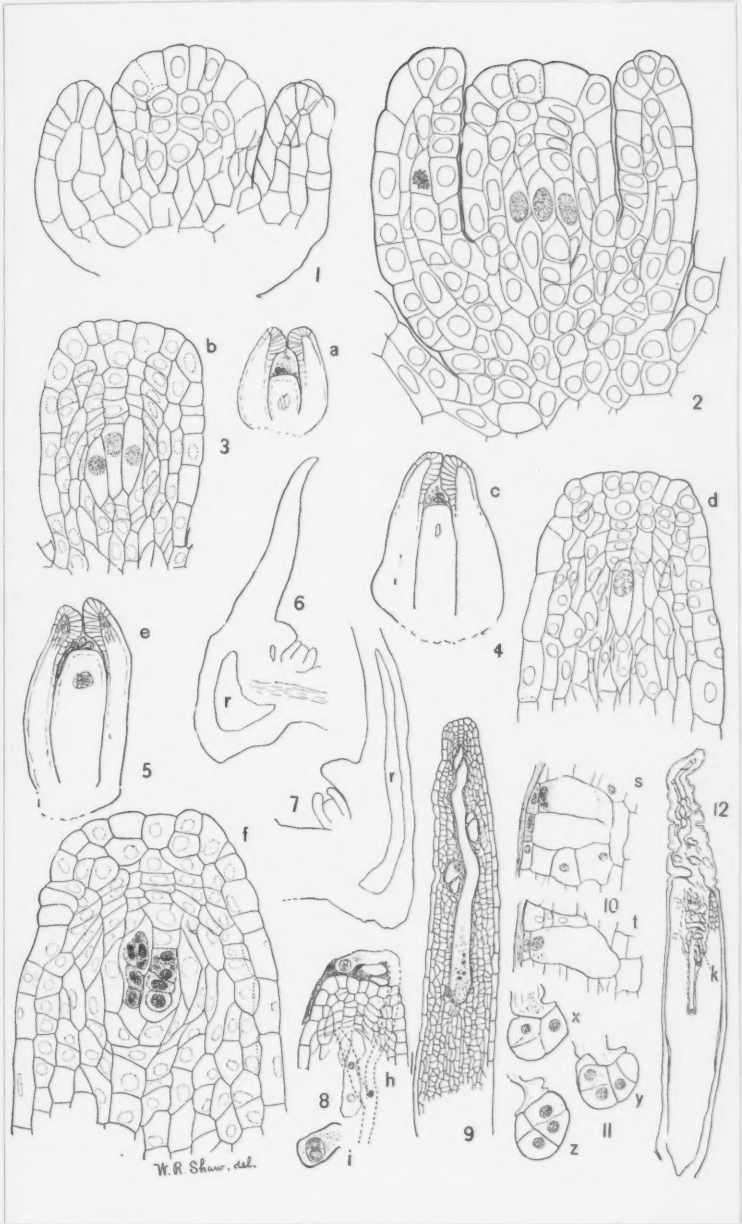
WALTER ROBERT SHAW.

WITH PLATE XXIV.

Sequoia sempervirens Endlicher and *S. gigantea* Decaisne are the only living representatives of a once larger and very widely distributed genus of the Coniferæ. Each species is limited to a narrow natural distribution in California. We have no account of the development of the sexual generation (prothallium), our knowledge of the reproduction in this genus being limited to accounts of the development of the flowers[1] and the germination of the seed[2] of *S. sempervirens*. The arboretum of Leland Stanford Junior University contains a large number of young fruiting trees of the latter species. It also lies within the zone of distribution of the species, there being one tree one hundred and forty feet high on the university grounds. At the suggestion of Dr. Douglas H. Campbell a study of the development of the macrosporangia (ovules) and the prothallia by microtome methods was begun in November, 1891, and carried on under his direction. The publication of the results was several times delayed in hope of being able to make them more complete.

The material for study was collected from young trees in the arboretum of Stanford University during the season of 1891–92. Collections were made in December, 1891 (not dated), and from January 9 to July 5, 1892, at intervals of three to seven days. The young flowers were split longitudinally, and the sporophylls were removed from the older flowers. The specimens were fixed in 1 per cent. chromic acid for eighteen hours, washed in water, and transferred gradually to 90 per cent. alcohol. For sectioning the alcoholic material was stained *in toto* in Czokor's alum-cochineal and imbedded, through the medium of turpentine, in paraffin. The sections were cut on a Minot microtome, stained on the slide with a solution of Bismarck brown in 70 per cent. alcohol, and mounted in Canada balsam.

[1] Strasburger, Die Angiospermen und die Gymnospermen 85. Jena, 1879.
[2] Strasburger, Die Coniferen und die Gnetaceen 327. Jena, 1872.



SHAW on SEQUOIA.

The female flower.

About the first of December, 1891, it was found that the macrosporangiate (female) flowers on larger trees were more advanced in development than those on the smallest trees which bore flowers. The sporophylls (cone scales) of these flowers are closely arranged spirally on an axis which is at this time about 4^{mm} in length, and are surrounded by scale leaves which are borne lower down on the same axis. Each macrosporophyll consists of a shorter basal portion perpendicular to the axis of the flower, and a longer terminal portion, closely appressed and parallel to the axis of the flower (compare figs. 6 and 7). On the ventral (upper) side of the basal portion is a transverse row of macrosporangia one to eight or ten in number, most numerous on the middle sporophylls of each flower. The middle sporangium on each sporophyll has its axis nearly parallel with, but slightly inclined toward, the floral axis. In the terminal portion of the sporophyll there is a resin-duct (*r* in figs. 6 and 7) along the dorsal (lower or outer) side of the single fibrovascular bundle. The abrupt bend between the basal and terminal parts of the sporophyll is somewhat thickened transversely in all directions. The sporangia are cylindrical and about as long as broad (figs. 1 and 2), and the integument reaches to a level with the flat top of the sporangium.

Just as the flowers had closed in February, Mr. B. M. Davis collected a hermaphrodite flower. In this flower the upper sporophylls are macrosporangiate and like those of the female flowers, and five of the lower sporophylls are microsporangiate (male) and, with the exception of the upper one which is in form like a female sporophyll, are similar to those of the regular male flowers. The relative positions of the two kinds of sporophylls is the same as the relative positions which the two kinds of flowers occupy on the branches of the tree; the female flowers are formed on the terminal shoot and neighboring twigs of each fertile branch, and the male flowers on the lateral twigs of the same branches. And correspondingly the lower branches of the tree bear more male than female flowers.

Early in January the microsporangiate flowers shed their pollen and the macrosporangiate flowers open to receive it. The opening of the flowers, male as well as female, consists in a separation of the sporophylls by intercalary growth of

the floral axis accompanied by an elongation of the basal portion of each sporophyll. The growth of the axis is greatest between the lowest sporophyll and the upper scale leaves, so that the flower is carried out of its envelope. In the macrosporangiate flower the basal part of the axis is negatively geotropic at this time and the flower assumes a more or less upright position. Open flowers were collected for about a month during which time the integument grows out beyond the sporangium forming a vestibule into which a thick fluid substance is excreted. In this the pollen grains are caught and held. About the time when the flowers open, the transverse thickening in the bend between the basal and terminal portions of the sporophyll begins to increase. This thickening develops in all directions nearly at right angles to the basal portion of the sporophyll and by it the flower is closed. This growth involves also that part of the base of the sporophyll which bears the sporangia and by it the sporangia are inclined toward the floral axis (figs. 6 and 7). When the flowers close, early in February, the middle sporangia on each sporophyll are about half way turned toward the axis, and about the first of March the micropyles are directed toward the floral axis. In the thickened part of the sporophyll secondary resin-ducts are developed and in the base of the sporophyll fibrovascular bundles are formed which end beneath the sporangia.

The cones continue to grow until about the first of June, at which time they are 21–24^{mm} in length and 15–17^{mm} in thickness. The cones open by shrinkage of the fleshy, obconical, middle portion of the sporophyll, which takes place at the end of the summer, in September, or later in the same year.

The macrosporangia.

In the young flowers the macrosporangia are circular in cross section and the integument reaches up to a level with the flat top of the sporangium. The sporangium is about as long as broad. The integument consists of the inner and outer epidermis and two layers of hypodermal cells. About the time the flowers open, January 1st, the integument begins to exceed the sporangium in length, and when the flower closes, about a month later, the integument is about twice as long as the sporangium. The micropyle then begins to close by radial elongation of the integument epidermal cells about it. In this way the pollen grains on the flat circular top of

the sporangium become enclosed in a subconical cavity, the micropyle. About the time when the micropyle begins to close, the hypodermal tissue of two opposite sides of the integument begins to grow in a radial direction to form the wings of the seed. In some cases the thickening of the integument occurs on three or four sides, in the directions of least resistance, but only two wings are developed. About the middle of February, when the micropyle has closed, the hypodermal cells in that part of the integument which surrounds it develop thick pitted walls which appear to be lignified (fig. 5, *e*). Up to this time the sporangium has grown slowly and it now begins to elongate by growth of the chalazal portion (fig. 3). The seed reaches its full length and width in June, when it is about 5^{mm} wide by 6^{mm} long.

In December the sporangium is cylindrical in form and about as long as broad, and surrounded by the integument which reaches about to the same level. Within the epidermis are five to seven central longitudinal rows of cells surrounded by one or two layers of smaller cells which are also arranged in longitudinal rows. Each of the central rows of cells appears to have originated in a single cell immediately beneath the epidermis, and the rows extend from the apex of the sporangium nearly to the chalaza, in which no regular arrangement of the cells can usually be traced. In the earliest stage observed the central rows consisted of two or three cells (fig. 1). Later stages show several cells in each row, of which the innermost, larger and longitudinally elongated, with a large nucleus, is a sporogenous cell, and the others are tapetal cells which are often somewhat flattened in shape with smaller and lenticular nuclei (fig. 2). During January the sporangium elongates slightly and there come to be about six tapetal cells between each sporogenous cell and the epidermis at the micropyle (fig. 3, *b*). About the first of February, after pollination has been effected, the growth of the sporangium becomes limited to the region between the sporogenous cells and the chalaza. The tapetum anterior to and alongside the sporogenous cells undergoes no farther growth and the cell walls of the anterior tapetum become somewhat thick and firm. By the basal growth of the sporangium the sporogenous cells come to occupy a position relatively near the apex of the sporangium (figs. 4, *c*, and 5, *e*). About the middle of March the cells immediately about the base of the

somewhat enlarged sporogenous cell or cells begin to weaken and disorganize (fig. 4, *d*), and each sporogenous cell divides twice to produce four macrospores (fig. 5, *f*). The first division is transverse and the second, which follows before the first wall develops to any thickness, is transverse in the lower cell and either transverse, oblique, or longitudinal in the upper cell.

The female prothallium.

A number of spores begin at once to develop female prothallia. They increase in length and grow toward the chalaza at the expense of the cells which lie in their paths, and the growing end of each becomes gradually larger. After about three weeks, April 8th, sacs are found with two nuclei (fig. 8, *h*). Already one sac is considerably larger than the others. The elongation of the sporangium continues and the embryo-sacs grow rapidly in length. Usually the largest sac in a sporangium grows down through the center of the sporangium, and the smaller ones grow obliquely or spirally downward alongside the larger one. By the middle of April there are eight or sixteen nuclei in the largest sac, all located near the lower or growing end of the sac, and the rest of the sac contains little protoplasm. One or even more of the smaller sacs may contain as many nuclei as the larger sac and they also are collected near the lower end (fig. 9). As the sacs elongate, the nuclei become more numerous and are distributed in a peripheral layer of protoplasm which line the whole length of each sac. About the end of May the longest sac reaches to the chalaza and the lower two-thirds or three-fourths becomes thicker. Usually the smaller sacs are confined to the upper third or quarter of the sporangium where they become tangled and surround the upper part of the principal sac. This upper part of the principal sac becomes atrophied and does not develop tissue. The formation of the cellular prothallium in the sac was not observed but it takes place about the first of June. When this occurs all or nearly all of the tissue of the sporangium has been absorbed except the epidermis and those cells which were anterior to the sporogenous cells. The upper part of the sporangium containing the secondary sacs and the "suspensor" of the primary sac becomes shriveled and bent. The cells of the prothallium usually show an arrangement in radial rows but do

not always. The cells in the upper end are as a rule larger than those in the lower end.

The date of maturation of the archegonia seems to vary as much as a month. The archegonia are numerous and usually arranged radially in the upper half or third of the prothallium, sometimes distributed to the upper end and sometimes not. They are, then, as a rule lateral. Only a few preparations showed the archegonia. In these the archegonia were nearly as long as half the transverse diameter of the prothallium and each consisted of a small neck cell and a large egg-mother cell (fig. 10, *s*, *t*). The farther development of the archegonia remains to be studied.

By July 5th the central part of the upper half of the prothallium contains several intertwined tubular suspensors each with an eight- or twelve-celled embryo on the lower end (figs. 11 and 12). The origin of the proembryos (suspensors with embryos) could not be traced in the sections. From prothallia macerated for a few hours in 10 per cent. caustic potash suspensors were obtained by dissection. They are unicellular and each contains a rather large nucleus near the middle, or the lower end. In nearly every case the wall of the upper end is ruptured as if by the penetration of a pollen-tube.

The pollen-tube.

At the time the pollen is shed in January each grain contains two apparent cells, a larger vegetative cell with a large nucleus, and a smaller, lenticular, parietal cell with a smaller nucleus. The germination of the pollen begins soon after the middle of February, and by the end of the third week in that month the pollen-tube reaches across the flat top of the sporangium and begins to grow down between the sporangium and integument. The vegetative nucleus passes into the tube and is usually to be found between the middle and the growing end of the tube. There is more variation in the rate of development of the pollen-tubes than of the principal embryo-sacs. During March the tube may reach half or two-thirds the length of the small sporangium and quite as often as not it branches, one branch growing on downward and the other taking any direction between the sporangium and integument, or penetrating the epidermis of the sporangium. About the time when the tube enters the sporangium the antheridial cell in the microspore enlarges and its nucleus divides (fig. 8, *i*, Apr. 8th). The two daughter nuclei, which

are smaller than the vegetative nucleus, move together into the tube. In a number of preparations these two nuclei were seen a short distance behind the vegetative nucleus near the place where the tube penetrates the sporangium wall. After entering the sporangium the tube passes obliquely downward and enlarges considerably. It soon becomes impossible to distinguish it in sections from the numerous windings of the several variously developed embryo-sacs with which it intertwines; and so it was not traced to the mature female prothallium. A study of the sectioned material is often made still more confusing by the fact that one or more of the secondary embryo-sacs with their free nuclei sometimes escape from the sporangia and grow around, up or down inside the integument. These are however larger than the pollen-tubes. An attempt was made to isolate the older pollen-tubes by macerating the sporangia in 5 per cent. and 10 per cent. caustic potash solutions but without success. It was found that this method showed clearly the course of the tubes before entering the sporangia but not farther. Some sectioned specimens show with little doubt that the pollen-tube usually or at least frequently grows down alongside the female prothallium, but as some of the secondary embryo-sacs with free nuclei often do the same thing nothing more definite was learned.

In some cases several of the embryo-sacs develop tissue, and again the single large prothallium may appear as several in sections by reason of constrictions produced by other immature sacs or by pollen-tubes.

The peculiarity of the pollen-tubes is that they do not penetrate the wall of the sporangium in the immediate neighborhood of the micropyle but at lateral points in the upper fifth of the sporangium. In this respect, and in the distinctly branched form which the tube develops,[3] Sequoia bears at least a remote resemblance to some of the so-called chalazogamous angiosperms.

With respect to the numerous archegonia and their irregular distribution in the prothallia we have in Sequoia an exceptionally generalized type of conifer. The division of each sporogenous cell into four macrospores, and the prolonged development of the secondary embryo-sacs, are characters as primitive as any we find among the Coniferæ. The abortion of the upper fourth or fifth of the principal embryo-sac into a

[3] S. Nawaschin, Botanisches Centralblatt **63**: 355. 1895.

suspensor-like structure the author does not know to occur in any other of the Gymnospermæ. The knowledge obtained of the development of the sporangia and prothallia indicates that the Taxodineæ have been very properly, if *Sequoia* is a fair type of the family, considered as a most primitive group of modern Coniferæ.

Stanford University, California.

Explanation of Plate XXIV.

Fig. 1. Longitudinal section of sporangium with integument. × 266. About Dec. 1, 1891.

Fig. 2. Longitudinal section through sporangium with integument, showing three sporogenous cells. × 266. About Dec. 10, 1891.

Fig. 3. *a*, longitudinal section through sporangium and integument. × 36. *b*, sporangium in same section showing three sporogenous cells. × 176. Feb. 16, 1892.

Fig. 4. *c*, longitudinal section through sporangium and integument. × 36. *d*, sporangium of same section showing one sporogenous cell. × 178. March 14, 1892.

Fig. 5. *e*, longitudinal section through sporangium with integument. × 34. *f*, sporangium of same section showing eight macrospores just formed from two sporogenous cells. × 180. March 14, 1892.

Fig. 6. Longitudinal section through sporophyll showing position of sporangium; the resin-duct, *r*, does not appear in its full length in this section. × 21. January 17, 1892.

Fig. 7. Median longitudinal section through sporophyll; *r*, resin-duct. × 21. January 17, 1892.

Fig. 8. *h*, longitudinal section through sporangium with male prothallia (pollen-tubes) and an embryo sac with two nuclei; the broken line indicates the course of a tube as followed in a different section, the tube being entirely outside of the sporangium; a nucleus at the point where the tube branches, and two nuclei in the antheridial cell; also two nuclei in the larger embryo sac. × 90. *i*, pollen spore of the same tube, drawn from two sections, showing the divided antheridial cell. × 154. April 8, 1892.

Fig. 9. Longitudinal section through a sporangium containing an embryo-sac with sixteen nuclei in the lower end, of which five appear in the section; two smaller sacs which wind about the larger one are cut in oblique section, one of the smaller sacs contains about sixteen nuclei, of which three appear in the section. × 41. April 15, 1892.

Fig. 10. Archegonia from a longitudinal section of a prothallium; *s*, from about one-fourth the length of the prothallium from the anterior end; *t*, about three-eighths from the anterior end. × 110. About June 21, 1892.

Fig. 11. Section of an embryo of eight cells from a longitudinal section of a prothallium; *x*, *y*, *z*, indicate the order of the sections. × 172. July 5, 1892.

Fig. 12. Longitudinal section through prothallium enclosed in sporangium of which the upper one-fourth is shrunken and occupied by abortive embryo-sacs; the upper half of the prothallium contains suspensors with embryos; *k* is the embryo section of fig. 11 *x*. × 15. July 5, 1892.

All drawings sketched with an Abbé camera lucida.

Notes concerning the development of Nemalion multifidum.

GRACE D. CHESTER.

WITH PLATES XXV AND XXVI.

The resemblance between the structure of the frond and the development of the cystocarp in the genera Batrachospermum and Nemalion is close enough to have led the earlier writers to place them in the same order, and this has also been done by Schmitz in his latest revision of the Florideæ.

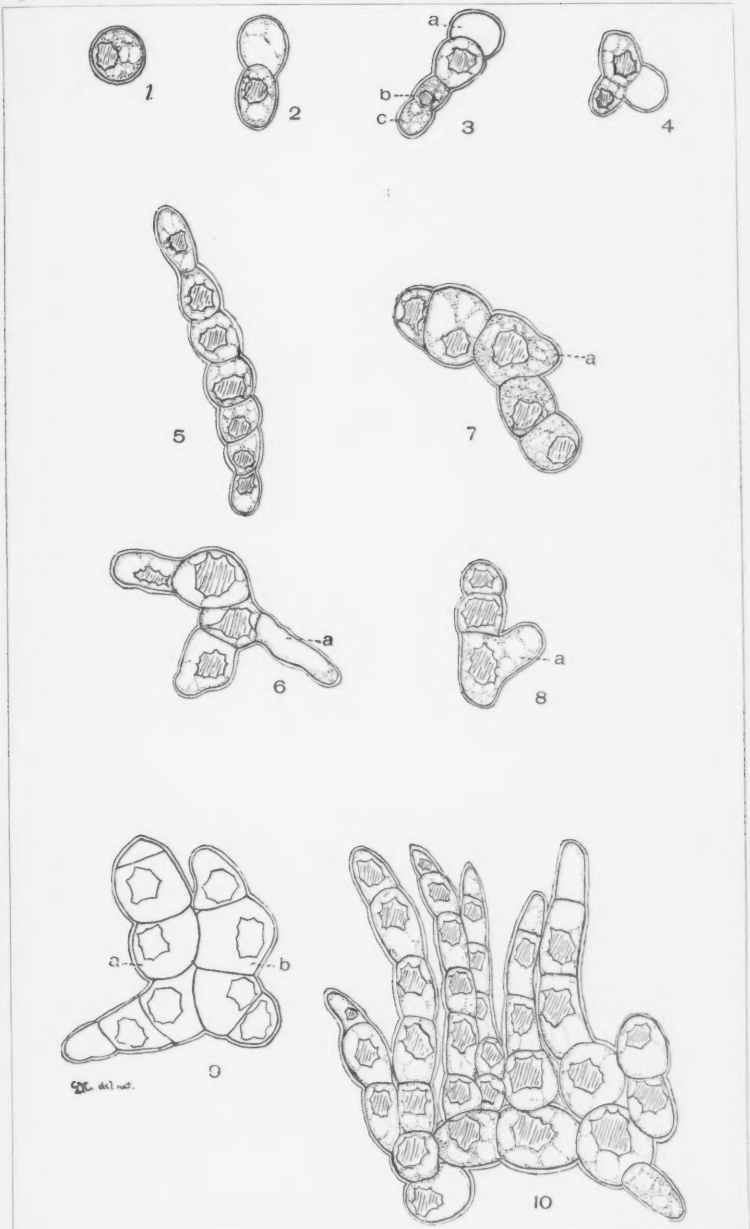
Through the researches of Sirodot it has been well established that there is a protonema or chantransia-stage resulting from the germinating spores of Batrachospermum. The surmise in regard to a protonematoid stage in the development of Nemalion also, made by Dr. Farlow in his "Marine Algæ of New England,"[1] has suggested the desirability of making an effort to trace the growth of the spores of this plant. The fortunate discovery of young Nemalion plants, together with an abundance of mature fronds, in the region of Woods Hole, Mass., led the writer during the summer of 1893 to attempt to obtain some further knowledge of this subject.

As far as the writer knows, up to the present nothing in regard to the germination of Nemalion has been published.

The only spores of which we know anything definitely are carpospores. Dr. Farlow quotes Agardh in regard to the presence of tetraspores in the genus Nemalion and says that "no tetraspores have been seen on American specimens of *Nemalion multifidum.*"[2] In this same connection it is said by Bornet and Thuret that they have never found tetraspores on any member of the Nemalieæ.[3]

The mature plants of *Nemalion multifidum* Duby consist of slender gelatinous fronds of a deep red-purple color. They often rise with numerous others from a slightly expanded base, which in the older plants is clean and sharply cut, but in the younger is often very irregular in outline. The plants are found attached to rocks or to the shells of barnacles. The

[1] FARLOW, W. G., Marine Algæ of New England 116.
[2] FARLOW, W. G., op. cit. 117.—HARVEY, Nereis Bor. Am. **2**: 134.
[3] BORNET & THURET, Etudes Phycologiques 65.



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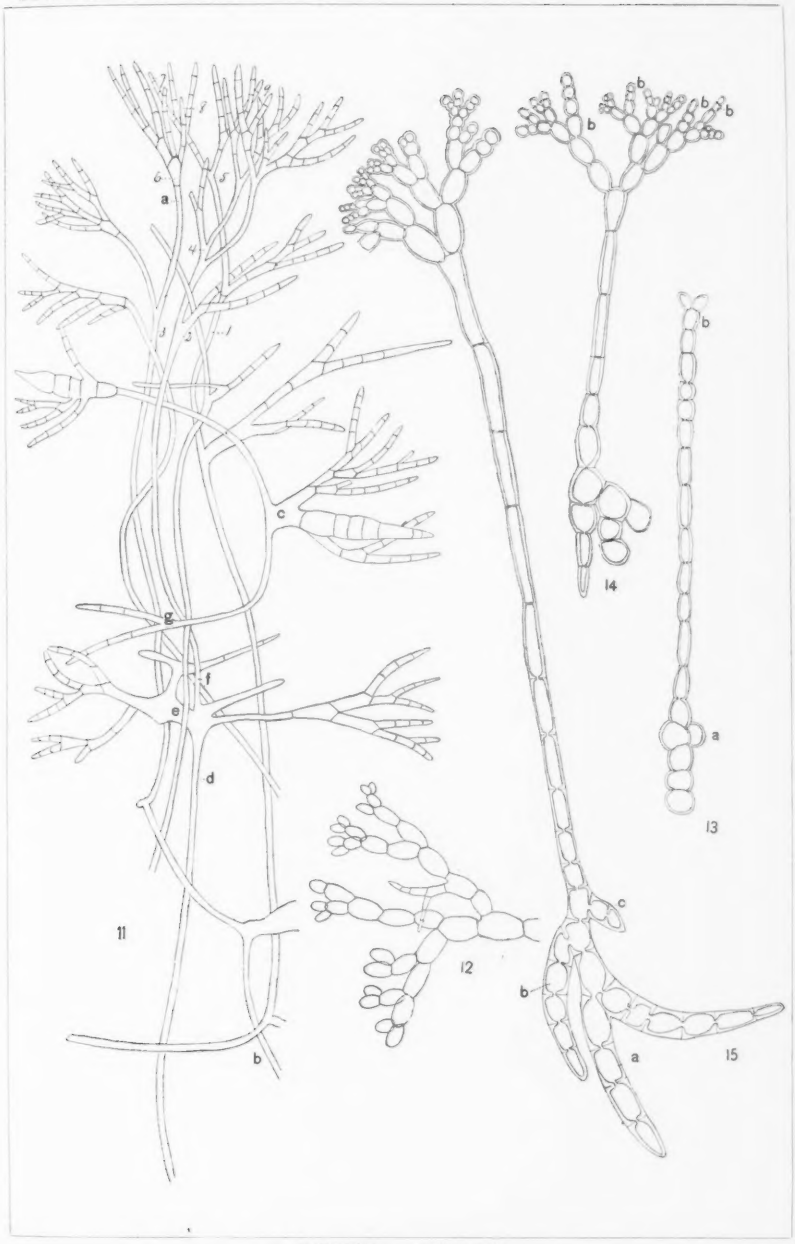


CHESTER on NEMALION.

fronds are from one millimeter to about forty centimeters in length, and from one to three millimeters in diameter. Dichotomous branching is the rule, but irregular branching may be found at various points. Branches occur with more frequency near the tip of the frond where the gelatinous sheath is thinner and where the central filaments can easily make their way to the outside. The writer has never found new branches arising near the very bases of old fronds. The appearance of a tuft of fronds as if all arising from one point, which is frequently seen on barnacle shells, is due to the fact that the young frond sometimes divides very early in its growth into several branches, separated by short intervals, and the expanded base is common to all these branches.

In order to study the earliest development of the Nemalion plants, it was necessary to devise some method of cultivating the spores. For this purpose shallow dishes were used, upon the bottom of which glass slides were placed. A gentle stream of sea-water ran constantly into the dishes, and the water was drawn off from the bottom of each dish over the edge by a siphon. Fronds possessing mature cystocarps were laid over the slides and the spores were shed upon the slides in large numbers. Other spores were collected upon slides placed in dishes which were not supplied with running water. In this case the water was very carefully drawn off and renewed four to five times every day. Spores obtained in this way were watched daily from the 1st until the 12th of August, 1893. The spores, immediately upon being shed, attached themselves to the slides, so that it was possible to keep the same spores under continuous observation, verifying in individuals the changes which were shown in a series of plants. The best results in growth were obtained from the slides which had not been supplied with running water, which was contrary to expectation, since the plants investigated grew on rocks that were exposed to strong buffeting of the waves.

The attached spore is spherical, 12μ to 14μ in diameter, with a stellate chromatophore situated nearly in the center. Bands of granular cytoplasm extend from the cytoplasmic substance surrounding the chromatophore to the peripheral layer of cytoplasm lining the cell wall. There appears to be a double wall to the spore, the inner one thin, while the outer one is firm and thick. Both walls are colorless and transparent. The chromatophore appears as a single body, occupying

a large portion of the cell and the deep red color of the whole cell is due to its presence. The nucleus of the spore and of the other cells of the plant is not visible in cells untreated by reagents and hence is not shown in any of the figures of this paper. Figure 1 shows the characteristic form and position of the chromatophore in a freshly attached spore.

The spore itself after remaining apparently unchanged for about twenty-four hours begins to elongate. It extends a protuberance at one end; the chromatophore a little later takes up its position near the tip of this elongating portion and is accompanied by nearly all the cytoplasm of the spore. The protuberance is next separated from the original spore portion by a transverse wall. At this stage, therefore, the sporeling consists of two cells, one a basal almost empty cell, the original spore, and the other, somewhat smaller, ellipsoidal in form (fig. 2). The original spore cell, which loses its chromatophore and a large part of its cytoplasm when the new cell is formed, persists for some time, after gradually losing its contents, as an empty spore-case (figs. 3, 4, 12, 13).

From the newly formed cell there arises in each case, by repeated division, a filament of cells branched or unbranched, each cell of which is similar to the one from which all have originated (figs. 3, 5, 6, etc.).

In many cases branches arise while the sporeling is still very young. Fig. 7 shows the first indication of such a branch in the protrusion of the process *a*. Fig. 8 shows a similar process, *a*, in a later stage, and in fig. 6 there is shown at *a* such a process completely cut off from the parent cell. The branch cell thus formed may contain a chromatophore (fig. 7, *a*), in which case the cell proceeds to divide, forming a series of cells (fig. 9, *a*, *b*), or it may be destitute of a chromatophore, and in this case it develops into a hair. Fig. 6, representing a plant seven days old, shows a typical cell of this sort at *a*.

The sporeling may also form a flat expansion of cells by branches developing in double rows from the original chain of cells as is shown in fig. 9, to which reference has already been made. This bears a decided resemblance to the more advanced structures found at the base of the Nemalion fronds attached to the barnacle shells where they grow. Fig. 10 shows one typical plant of this sort, many of which form red spots on the barnacles, suggestive of the similar spots de-

scribed by Dr. Farlow as occurring at the base of the fronds of *Mesoglœia divaricata* Kütz., which, as also suggested by him, have a definite connection with the growth of the mature frond of that plant.[4]

After the sporeling has developed from three to ten rounded cells, cells of a decidedly different type are developed in the continuation of the filament. These are long, narrow and contain less dense cytoplasmic contents and smaller, less deeply colored chromatophores (figs. 13, 14, 15). In fig. 13, the rounded cells are followed by elongated forms which at *b* are surmounted by two cells which have developed as buds from this last cell of the filament, *b*, and this is the first case of the development of dichotomous branching in the sporeling. From this elementary stage of branching are traced in other sporelings more advanced stages, showing degrees of perfection of dichotomous and of fascicled branching, approaching more and more in their appearance the fascicled branches of the filament of the mature frond, to be described later. Figs. 13, 14, 15 and 12 show such a series, taken from numerous plants of similar structure.

The basal processes of these sporelings are of interest at this point. Fig. 13 shows three of these cells extending back of the spore, *a*. Fig. 14 shows two such processes and three marked branches or rhizoidal processes are found in fig. 15, *a*, *b*, *c*. These are similar to the branched rhizoidal growths formed abundantly at the bases of mature Nemalion plants, and these latter growths are doubtless identical in formation with these sporeling processes.

Fig. 14 is the most interesting form in this series, as the fasciculate branching at its tip shows certain unbranched or single arms, *b*, *b*, *b*, *b*, which, by increase in length, may meet and twist together, forming the elementary condition of a mature frond. These arms would later divide and produce dichotomous fascicles with occasional single arms, which would continue in the manner of the early sporeling to increase in length and thus increase the frond in length and diameter.

In order to throw some light on this very point of the growth of the mature plant in its earliest stage, the growth of the tip of the frond, showing the method of increase in length of the whole plant, was next investigated. The gelatinous mass, which surrounds every filament of the plant, makes it

[4] Farlow, W. G., Marine Algæ of New England 84.

difficult to see the real structure of the tip region. The tip may be seen, however, by directly crushing the frond. This removes too many of the branchlets or disturbs too much their relative position. The application of boiling water to dissolve a large amount of the gelatinous substance allows us to examine the tip with every axial filament and branch in its natural position.

The tip of the plant is never conical. The number of axial filaments and their branches is so great even in the youngest plants examined, that extreme care is necessary to distinguish those occupying the exact tip. It is certain that no single filament at the tip exceeds the others in size, and that there are present at the extreme tip of the plant a number of filaments almost exactly alike (fig. 11). The smallest number of filaments possible to trace to the very tip was three (fig. 11), the lower filaments and the final branchlets of each filament having been gradually removed by gently crushing the plant which had been treated with hot water.

Turning now to the adult frond below the tip, we find that it is made up of distinct axial and cortical layers. Each of these layers is made up of branching filaments. In the axis the filaments are made up of long narrow cells, from 30 to 125μ in length, containing small colorless chromatophores (fig. 11, *a*, *b*). The walls marking the cell divisions of these threads are so far apart (often 125μ) as to have made Agardh's statement[5] a most natural one. "The filaments proceeding downwards are inarticulate and cylindrical; those growing upwards are articulated, and more or less contracted at the dissepiments." These central cells divide at irregular intervals, giving off, often without separation by a cell wall, branches which may proceed undivided in the central region or turn towards the periphery, and divide dichotomously (fig. 11, *c*, *d*). Several divisions of a central thread may occur at very short intervals as shown in fig. 11, where five such arms are separated off from the main thread near *e*. Certain of these arms proceed up or down the main axis for a long distance without dichotomous branching, *d*, *f*. Fig. 14 shows the origin of the single arm, as we shall call it, at *b*, *b*, *b*, *b*, together with the other arms or branches which directly form the perfect fascicle. The "downward growing" arms turn to the periphery as much as do the "upward growing" arms, and

[5] HARVEY, Nereis Bor. Am. 134.

form fascicles of branches by dichotomous division (fig. 11, *g*).

Thus tracing these different filaments to the tip, we find at the very last three main axial threads (fig. 11, *1*, *2*, *3*) bearing lateral fascicles and ending in three distinct fascicles, *4*, *5*, *6*, each bearing single arms, *7*, *8*, *9*, like those formed lower down on the frond. These single arms, *7*, *8*, *9*, by their increase in length will extend upward beyond the divided arms or fascicles of branches, and by later division increase the length of the whole frond.

Increase in diameter is produced by the pushing to the periphery of direct or lateral branches of the axial filaments. These divide dichotomously to form new fascicles (fig. 11, *c*, *g*, etc.). Very young tufts are thus found with fully fruited ones at the base of even the oldest fronds. Young undeveloped trichophores are found in the next fascicle to one bearing ripe cystocarps. Agardh's description of the mode of the development of the Nemalion frond is interesting, at this point.[6]

Agardh states that the frond consists of three regions, "central, lateral and peripheral." The peripheral branches grow first, and send their branches inward, making the increase in diameter of the frond "like that of an endogenous tree from the outside to the inside."

A definite resemblance between the structure of the tip of the frond and the sporeling tip both in respect to the fasciculate branches shown in detail in figures 12, 13, and 14, and in respect to the single arms or unbranched filaments occurring with these (figs. 14, *b*, *b*, *b*, and fig. 11, *7*, *8*, *9*,) is clearly seen. Both of these conditions have been already described. The possibility of the development of the erect or mature frond from the sporeling plants must now be noticed. The increase in length and subsequent division of any of the filaments of a sporeling plant to form a complete frond has already been mentioned (fig. 14). The meeting of several

[6] "The different strata of the frond seem to me to be formed in an opposite direction. First, unless I am deceived, the peripheric stratum begins to be developed from the base upward by progressive evolution; some of the branches emitted by the peripheric filaments constitute the peripheric stratum, but others are erected with a direction more vertical, giving off on their outer side new peripheric filaments, and on their inward side longitudinal filaments. These latter, at first, by an ob ique course are directed towards the center of the axis; then they take a downward direction, by a longitudinal course. In some respects, therefore, the growth of an endogenous stem is imitated."

such sporeling plants and the consequent interlacing of the filaments belonging to each seems a very probable method of formation for a plant with the axial structure of Nemalion. It also seems probable that the increase in length of the filaments developed on any of the plants found on the barnacle shells which there form red spots (fig. 10), the subsequent division into branchlets, and the interlacing of these filaments may give rise to an erect frond of Nemalion. The possible origin of Mesogloia from similar "spots" has already been mentioned.

In conclusion I would compare or homologize the prostrate series of rounded cells developed from a spore of Nemalion forming a short filament or a flat expansion of cells with that series of prostrate cells formed from the Batrachospermum spore and called by Sirodot a prothallus or protonema, and described by him as such in "Les Batrachospermes." The resemblance seems so exact as to admit of calling this stage in Nemalion also a protonema. From this there arises the branched sporeling already described. The chantransia stage of Batrachospermum is an erect plant, branching irregularly and bearing the sexual plant as a bud. This sexual plant has an axis of single cells placed end to end, covered by the branches which grow up and down its surface. In Lemanea, the chantransia is a similar branching plant, bearing the sexual plant as a bud. The resemblance between this stage in Lemanea and Batrachospermum and the branched sporelings described in this paper is so close as to admit of calling these branched sporelings the chantransia stage of Nemalion.

It remains my pleasant privilege to thank Dr. W. A. Setchell of the University of California for his suggestive direction of the work done on Nemalion at the Marine Biological Laboratory, at Woods Hole, Mass., in 1893, for material collected by him in 1894, and for criticism during the development of these observations.

Smith College, Northampton, Mass.

Explanation of Plates XXV and XXVI.

Plate XXV.

Fig. 1. Carpospore of *Nemalion multifidum*. × 400.

Fig. 2. Spore in early stage of germination; three days old. × 400.

Fig. 3. Sporeling in later stage of germination (protonema); three days old. × 400. *a*, empty spore case; *b*, second cell of plant; *c*, colorless protuberance developing into third cell of the plant.

Fig. 4. Another common form of sporeling or protonema; three days old. × 400.

Fig. 5. Characteristic filamentous sporeling or protonema; five days old. × 400.

Fig. 6. Branched protonema with hair cell, *a;* seven days old. × 400.

Fig. 7. Filamentous protonema showing origin of branch, *a;* nine days old. × 400.

Fig. 8. Filamentous protonema with branching process, *a*, further developed; nine days old. × 400.

Fig. 9. Protonema forming flat expansion of cells; ten days old. × 400.

Fig. 10. Protonema with seven branches forming flat expansion on barnacle shell. × 400.

Plate XXVI.

Fig. 11. Tip of frond crushed to remove extra filaments and tip branchlets. × 130.

Fig. 12. Detail of typical lateral or tip fascicle of mature frond. × 240.

Fig. 13. Filamentous growth from sporeling showing first indication of dichotomous branching. × 240.

Fig. 14. Older sporeling or "chantransia" stage, with perfect fascicle of branchlets and well developed rhizoidal branches. × 240.

Fig. 15. Chantransia more advanced than the preceding, with several rhizoidal branches. × 240.

*** Figs. 1–9 from nature, with Abbé camera. Material under cultivation in 1893.

Fig. 10 from nature, with Abbé camera. Material on barnacle shell.

Figs. 13–15 with Abbé camera. Material cultivated in 1894 by Dr. Setchell and preserved in chrome-alum.

Synopsis of North American Amaranthaceæ. V.

(Concluded.)

EDWIN B. ULINE AND WILLIAM L. BRAY.

IRESINE L. Gen. Pl. n. 1113. 1737.

Lithophila Sw. Prod. Veg. Ind. Occ. 14. 1788.
Philoxerus R. Br. Prodr. Flor. Nov. Hol. **1**: 416. 1810.
Tromsdorfia Mart. Nov. Gen. et Spec. Bras. **2**: 40. 1826.

Hermaphrodite, polygamo-dicœcious or dicœcious herbs, shrubs or shrubby trees, the latter attaining a height of six meters, with opposite usually petioled leaves, scarious whitish 3-bracted flowers crowded into clusters or spikes in a branching paniculate inflorescence: calyx of five sepals which in ☿ and ♀ flowers are generally almost hidden in long wool which springs from the base of the flower: stamens five; filaments united into a shallow cup at base and bearing staminodia in most species: utricle globular, ovate or urn-shaped with short style and two slender often filiform stigmatic branches.

In this synopsis of the genus *Iresine* we have followed the plan stated previously of including such Mexican and Central American species as were found to be well represented in the herbaria of the United States, so that while we reduce the forms found in the United States to *Iresine vermicularis* (L.) Moq. and *Iresine paniculata* (L.) Kuntze, with its two varieties, there are here included some eleven other tolerably well defined species from Mexico and Central America, four of which we venture to describe as new, knowing well that a more thorough acquaintance with the Iresines of those regions may show us to be in error. As a matter of interest we would call attention here to the rather surprising fact that from Honduras and Guatemala Iresines are reported which are actually shrubby trees and in one case a small tree six meters in height.

* *Hermaphrodite.*

+ *Inflorescence capitate.*

IRESINE VERMICULARIS (L.) Moq. DC. Prodr. **13**[2]: 340. 1849.

Gomphrena vermicularis L. Sp. 224. 1737. no. 6.
Philoxerus vermicularis R. Br. Prodr. Flor. Nov. Hol. **1**: 410. 1810.

Low fleshy seaside herbs with narrow sessile leaves, capi-

tate inflorescence and ☿ flowers: sepals five, unequal, the flower flattened dorso-ventrally: stamens five, staminodia none.

Florida, West Indies, Guiana, Brazil; also on lower Rio Grande and in Panama.

On the supposition that the specimens examined were accurately named, this will embrace *Iresine portulacoides* (St. Hil.) Moq. l. c. and *Iresine aggregata* (Willd.) Moq. l. c. With our present view of Iresines, the descriptions in DC. Prodr. **13**^{2}: 340, 341 do not indicate satisfactory specific differences.

+ + *Inflorescence paniculate.*

Iresine completa, n. sp.

Shrubby, with rather dense appressed grayish pubescence: leaves long and narrow elliptical-lanceolate, glabrous except the under surface of young and midrib of older leaves, these and the stem blackish in the dried specimens: inflorescence a narrow panicle with short strictly opposite branches and branchlets, each pair subtended by short acute scarious bracts, or by reduced leaves lower on the main axis; spikelets pedicellate in the axils of bracts, or terminal on the ultimate branchlets: flowers ☿, rather large, 2.5^{mm} long, bracts broadly ovate, less than half the length of the perianth: calyx with glabrous sepals, nerved and with scarious margins, on a distinct pedicel from which arises a dense growth of long woolly hairs: utricle as in the next species, from which this differs in its complete hermaphroditism, pubescence and narrower inflorescence with opposite arrangement: stamen cup rather deep and the staminodia prominent.

Honduras, San Pedro Sula, *Dr. Carl Thieme* no. 338 (1888). Type in John Donnell Smith herbarium.

IRESINE ELATIOR Rich. in Willd. Sp. Pl. **4**: 766.

Rosea elatior Mart. Nov. Gen. et Spec. Bras. **2**: 59. *pl. 155.* 1826.

Stem herbaceous, erect, striated, glabrous: leaves oblong-lanceolate and narrower: panicle pyramidal; spikelets alternate, short pedicellate; flowers ☿: staminodia present but very minute: utricle orbicular.

Mexico, Lower California, Central America, West Indies.

* * *Polygamo-diœcious.*

+ *Shrubs or shrubby trees.*

Iresine nigra, n. sp.

Shrubs, sometimes shrubby trees, undergrowth in forests, turning black on drying, glabrous except among the flowers: leaves much as in the preceding but thicker, smaller and with longer petioles: inflorescence a lax panicle with very long, slender alternate branches loosely set with small spikelets, which are pedunculate only at the base of branches: flowers sometimes ☿, but apparently generally unisexual by failure of pollen or ovules to mature, some plants being prevailingly pistillate, others staminate: bracts and sepals in ☿ and ♀ flowers as in the preceding, but the flowers are smaller, 1.5^{mm} long; in those flowers which are more conspicuously staminate the sepals are longer, narrowly oblong, somewhat pilose, but the woolly growth from the base is inconspicuous: utricle top-shaped, narrowed below into a stalk-like base and above into a short style with two long filiform stigmatic branches: staminodia very minute.

Honduras, San Pedro Sula, *Dr. Carl Thieme* nos. 312, 314 (1888) 1061, 38 (1887); Guatemala, *Heyde & Lux* 4573 (1893); Orizaba, *Botteri* 990. Types in J. D. S., Coulter, and Gray herbaria.

Iresine arbuscula, n. sp.

A small tree 4.5 to 6^{m} high with large oblong-elliptical green leaves 14–21^{cm} long including petiole 3–4^{cm} long; branches and petioles black in dried specimens: inflorescence a pedunculate naked drooping panicle at the ends of leafy branches, the larger branches of the panicle subtended by scarious bracts, never by reduced leaves as in *I. paniculata* which it resembles considerably in inflorescence; branches of inflorescence long, filiform, not divaricate: spikelets very small and closely set along the ultimate branchlets; rhachis short woolly, but pedicel of flower little hairy. The specimen examined seems to be staminate, although the utricle is so largely developed as to possess papillate stigmatic branches so that there is no apparent reason why seed should not be produced, but the flowers seem to fall off after anthesis. Staminodia rather prominent, long and broad.

Guatemala, Volcan Tecroamburro, Santa Rosa, *Heyde & Lux* 4570. (1893).

+ + Herbaceous or suffruticose.

Iresine jaliscana, n. sp.

Herbaceous or suffruticose with green stems longitudinally ridged: leaves green, small, ovate-lanceolate, 3 to 8^{cm} long including petiole, appearing in fasciculate clusters at the nodes, these and the stem glabrous except on the very youngest growths: inflorescence a lax mostly leafless panicle with very slender branches, those of the second order long divaricate, bearing pedicelled spikelets mostly on one side; rachis of spikelets woolly, bracts acuminate, nearly as long as the sepals: sepals membranous, narrowly oblong; calyx slightly pedicellate with comparatively inconspicuous hairiness at base: in ♀ flowers the stamen cup is present bearing five imperfect stamens and very minute staminodia: utricle flat top-shaped, terminating above in a short style with two filiform stigmatic branches: ♂ plants not seen.

Mexico, state of Jalisco near Guadalajara, *Palmer* no. 92 (1886). Types in Columbia College, U. S., and John Donnell Smith herbaria.

* * * *Diœcious.*

+ The whole plant (except older woody portions) densely white or gray tomentose.

++ Staminodia papillate, i. e., dissected into fine hair-like processes.

IRESINE CANESCENS Humb. et Bonpl. in Willd. Sp. Pl. **4:** 765.

Tromsdorfia canescens Mart. Nov. Gen. et Spec. Bras. **2:** 42. 1826.

Distinguished by its sub-pyramidal very profuse paniculate inflorescence. The male flowers have prominent but abortive utricles showing even rudiments of stigmatic lobes: the staminodia are prominent and finely dissected into hair-like papillæ. In the female flowers the white woolly growth from the lower portion of calyx lobes and base of the flower is unusually conspicuous and dense.

Mexico, Lower California, Central America.

IRESINE CASSINÆFORMIS Schauer in Linnæa **19:** 708. 1847.

Determined by Sereno Watson, who notes, "imperfectly agreeing with the description." It has the flower characters of *I. canescens* but differs in habit, being more woody, with nar-

rower thicker leaves which are white tomentose beneath: the branches of female inflorescence are condensed into narrow panicles much less profuse than in typical *I. canescens*, of which it is possibly only a form.

Mexico, Monterey, *Palmer* 1133 (1880).

IRESINE SCHAFFNERI Wats. Proc. Amer. Acad. **21:** 437. 1886.

Suffrutescent: panicles mostly long pedunculate, the spikelets sessile and somewhat crowded upon the short branches: female flowers as in *I. canescens:* male flowers more pubescent on the sepals and longer bracted. The long pedunculate panicles seem to distinguish this plant from the two preceding.

Mexico. Types in Gray, J. D. S. and Columbia College herbaria.

++ ++ *Staminodia entire.*

IRESINE PRINGLEI Wats. Proc. Amer. Acad. **25:** 161. 1890.

Shrubby, finely tomentose, the very young leaves densely white tomentose, becoming bright green and nearly glabrous above and thinly tomentose beneath, lanceolate: sepals of female flowers rigid, 1^{mm} long, acuminate, spreading tips, a prominent bright green mid-nerve and white margins, very woolly, especially near the base. The species is well marked by the peculiar calyx of the female flower.

Reported from several states in northern Mexico. Types in Gray, J. D. S., and Columbia College herbaria.

IRESINE LATIFOLIA Benth. & Hook. Gen. Pl. **3:** 42. 1883.

Alternanthera latifolia Moq. l. c. 351. 1849.
Gomphrena latifolia Mart. & Gal. Bull. Acad. Brux. (Reprint p. 9). 1843.
Iresine laxa Wats. Proc. Amer. Acad. **21:** 454. 1886.

Suffruticose or woody, tomentose, leaves from broadly ovate to ovate-lanceolate, those on the flowering branches narrower and reduced: panicle more diffuse than in *I. canescens*, with flowering branches slenderer and more lax: flowers aggregated in spikelets, alternate and pedunculate along the opposite branchlets of the diffuse panicle: sepals of male flowers short hairy: staminodia long and narrow, not papillate: sepals of female flowers thin, densely long woolly. Those

specimens described as *I. laxa* by Watson are like certain specimens which he called *I. latifolia*, agreeing also with those sheets from other herbaria labelled *I. latifolia*, which leads us to believe there is no distinction of species here.

Mexico, Lower California.

++ *Plants mostly glabrous.*

IRESINE INTERRUPTA Benth. Bot. Voy. "Sulphur" 156. 1844.

Alternanthera Richardii Moq. l. c. 353. 1849.

Suffruticose, erect, glabrous: leaves bright green and also glabrous: primary branches of inflorescence opposite and widely divaricate; secondary alternate, loosely set with spikelets of small unisexual flowers, the rachis and base of the flowers pilose: staminodia broad, dentate at summit.

Mexico.

IRESINE PANICULATA (L.) Kuntze Rev. Gen. Pl. 454. 1891.

Iresine celosioides L. Sp. Pl. 1456. 1762.

Mostly glabrous erect annuals or perennials according to habitat, those of the southwestern desert regions with stronger tendency to the latter: stem nerved or angled, often swollen at the joints; plant diffusely branching, often with small undeveloped branchlets in the axils of leaves: leaves petioled, tapering at both ends, ovate to lance-linear: inflorescence paniculate, always with reduced green leaves subtending the larger branches; spikelets oblong or linear, seldom pedicellate and never properly glomerate: in the male flowers there are mostly five stamens (sometimes only three?): staminodia if present very minute: usually no rudimentary ovary: sepals of female flowers 3-nerved, woolly: stamen cup exceedingly rudimentary, with five lobes indicating rudimentary stamens by their position: no ♀ flowers: polygamous plants have not been seen. The most clearly marked dicœcious species of the Iresines.

Widely distributed over the southern half of the United States from Atlantic coast to New Mexico and south. Not reported north of Kentucky, Arkansas and southern Kansas.

IRESINE PANICULATA, var. **Floridana,** n. var.

Diffusely branching from a woody base, branches ascending and equal: roots long and fleshy: nodes crowded, less than

3^{cm} apart: leaves small and crowded: pistillate flowers clothed with long, straight, white wool.

Anastasia Island, Fla., Miss Mary C. Reynolds, 1875.

Labeled *I. diffusa* in J. D. S. herb. and *I. flavescens* in Columbia Coll. herb. Types in above herbaria.

IRESINE PANICULATA, var. OBTUSIFOLIA Coulter Bot. West. Tex. 364. 1894.

Lower leaves smaller, ovate or broadly spatulate, obtuse, more scabrous, especially beneath on the prominent white veins: panicle narrower, more leafy.

The species shades gradually into this variety, which however may stand as the type of a departure from the normal quite general among the southwestern forms.

Western Texas to Chihuahua.

Since *Iresine paniculata* is so widely distributed, it is naturally found to vary considerably in specific characters, so much so that without a large number of specimens for comparison one would be inclined to choose out certain forms for specific distinction. But with the large amount of material from various regions at our disposal there seems abundant reason to say that the following forms are to be included in the synonomy of *I. paniculata.*

Iresine flavescens Humb. et Bonpl. ex Willd. Sp. Pl. **4:** 766.

Alternanthera flavescens Moq. l. c. 350. 1849.—Those plants called *A. flavescens* Moq. by Chapman, and others so labeled (probably on the strength of Chapman's determinations) may be referred to *I. paniculata.* It is not certain that Chapman's type is identical with the original, but it accords well with the descriptions.

Iresine diffusa Humb. et Bonpl. l. c. **4:** 765.—Nuttall's plant which Moquin has cited under *I. diffusa* is identical with our specimens called *I. flavescens.*

Iresine gracilis Mart. and Gal. Bull. Acad. Brux. **10:** 347. 1843.—Here again all the specimens examined may be referred to *I. paniculata.* We are bound to say however that while we feel warranted in the present disposition of these species, we lack the important evidence of an examination of the types. These are not in American herbaria.

DICRAURUS Hooker f. Benth. et Hook. Gen. Pl. **3:** 42. 1883.

Apparently differing from the shrubby Iresines only by its

alternate leaves. Not completely diœcious as previously described, for some plants have ☿ flowers. Staminodia present in all the flowers, papillate.

In this genus, as in Iresine, there are characteristic male and female inflorescences differing obviously from each other. Occasionally in both genera one finds a plant in which the characteristic male flower has a functional utricle, but more often the female flower is found producing functional stamens. In one of the Dicraurus specimens (Nealley, Chenates region Western Texas [1889] Coulter herb.), although the plant is evidently of the female type, all the flowers have from two to five pollen-bearing stamens.

DICRAURUS LEPTOCLADUS Hook. f., l. c.

Leaves very small, ovate or ovate-lanceolate, 12–25^{mm} long. Flowering branches rather long and stout, with compact inflorescence. *I. alternifolia* var. *Texana* Coulter. Referred to above as having ☿ flowers.

Western Texas and Mexico.

DICRAURUS ALTERNIFOLIA (Wats.).

Iresine alternifolia Wats. Proc. Am. Acad. **24**: 72. 1889.

Leaves larger, ovate or oblong, truncate or cuneate at base, occurring in fascicles which subtend the flowering branches, these being short, slender and divaricate, much branched: flowers smaller than in the preceding, the female with more conspicuous woolliness.

Mexico, Guaymas, *Palmer* 276 (1887).

In concluding the synopsis of North American Amaranthaceæ we append a brief account of two genera which were not included in order, earlier in the revision; namely, *Celosia* and *Acanthochiton*.

CELOSIA L. Gen. Pl. no. 289. 1737.

Distinguished from our other genera by its two to several seeded utricle.

CELOSIA PANICULATA L. Sp. Pl. 206. 1753.

Our most common species. Florida, Southern Texas, Mexico.

CELOSIA PALMERI Wats. Proc. Amer. Acad. **18:** 143. 1883.

Differing from *C. paniculata* in foliage, inflorescence and broader and less acuminate bracts and sepals.

North Mexico.

CELOSIA FLORIBUNDA Gray Proc. Amer. Acad. **5:** 167. 1861.

Very distinct in foliage and its abundant compact inflorescence.

Lower California.

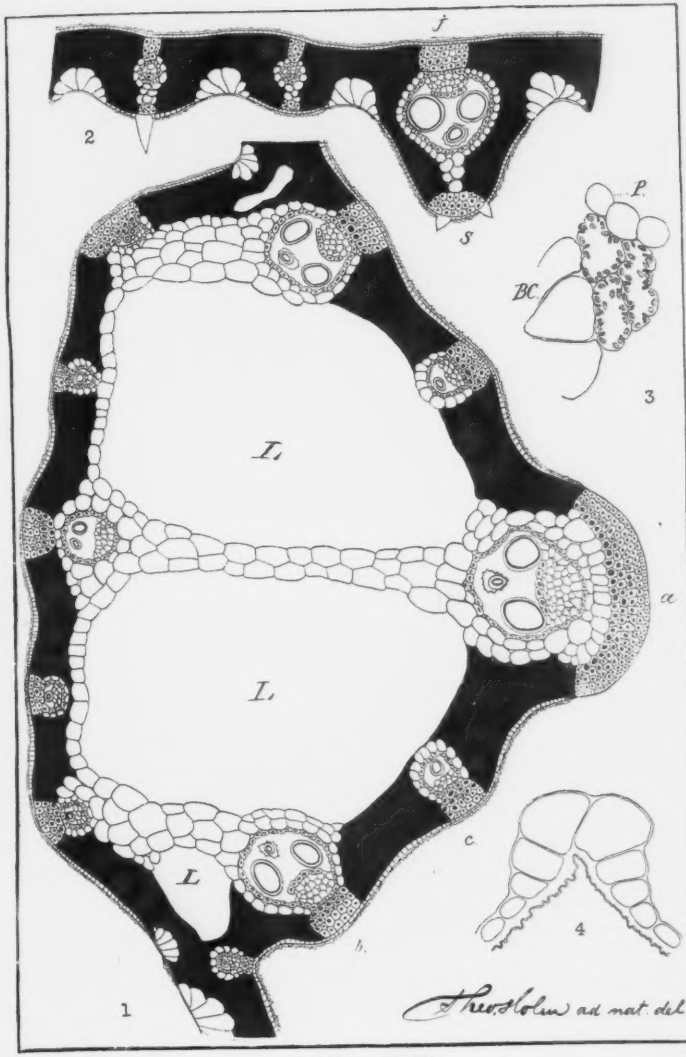
ACANTHOCHITON Torr. Bot. Sitgr. Rep. 170. *pl. 13.* 1893.

A monotypic genus between *Amaranthus* and *Acnida.* Dicœcious; distinguished by the remarkable bract development in the ♀ flowers.

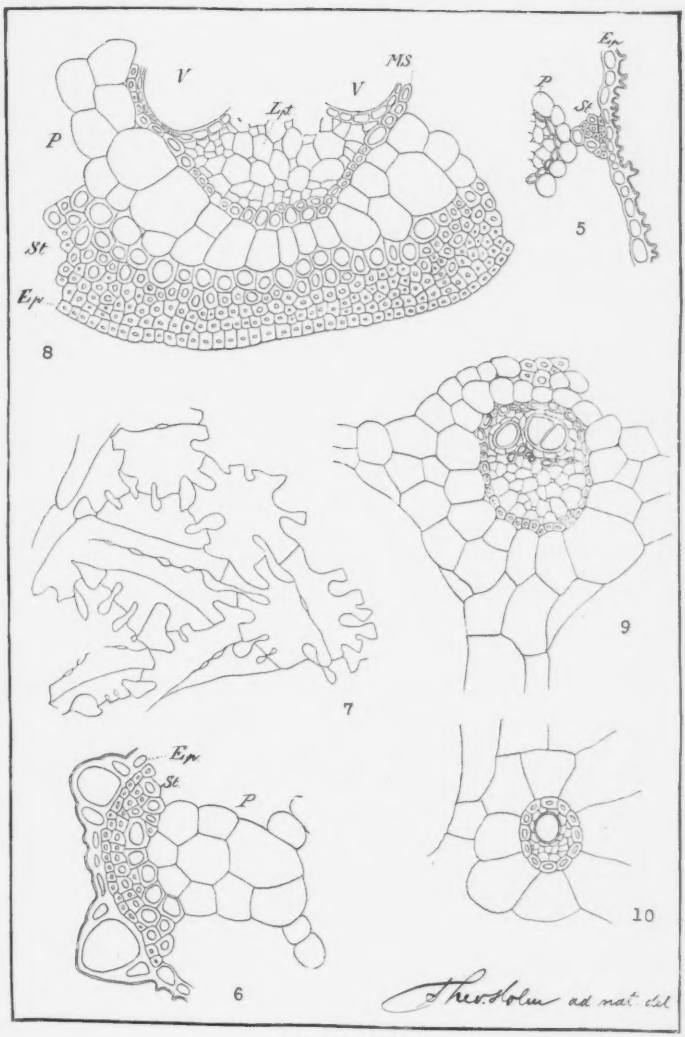
ACANTHOCHITON WRIGHTII Torrey. l. c.; also in Bot. Mex. Bound. 179. 1859.

Texas.

Herbarium Lake Forest University.



HOLM on ORYZA.



HOLM on ORYZA.

A study of some anatomical characters of North American Gramineæ. VI.

THEO. HOLM.

WITH PLATES XXVII AND XXVIII.

Oryza sativa L.

The leaf of this grass shows a very great resemblance to that of *Leersia oryzoides* Swtz. which we have described in a previous article upon the leaf-structure of the genus Leersia.[1] The leaf of Oryza (fig. 1) shows the large development of the median part, containing not only a mass of colorless parenchyma, but also several mestome bundles on the superior face of the blade. But it differs by the presence of the large lacunes, the larger number of mestome bundles on both faces of the keel, and the absence of bulliform cells on the inferior face of the blade. We remember that in Leersia there was one group of bulliform cells developed on each side of the keel on the superior and the inferior face.

Considered by itself, the leaf of *Oryza* may be characterized as follows: The epidermis, seen *en face*, represents two forms, viz.: strata of short broad cells with undulated radial walls which cover the mesophyll and in which the stomata are to be observed, and strata of long and very narrow cells which cover the stereome. A transverse section of these strata (fig. 5) shows the narrow lumen of the last mentioned form, that which lies outside the stereome in contrast to the other one, outside the mesophyll. The bulliform cells (fig. 4) occur only on the superior face between the mestome bundles, and none are to be observed above the keel. Epidermal expansions are numerous, as roundish warts or as curved thorn-shaped bodies; the last are confined, however, to the strata outside the stereome. The stomata seemed to be equally distributed on both faces of the leaf-blade, but as stated above, they occur only in the strata outside the mesophyll, excepting where the bulliform cells are situated.

The mestome bundles are very variable in size, a fact which

[1] Bot. Gazette **17**: 358–362. N1892.

is especially noticeable when we examine the median part of the leaf (fig. 1). There are two midribs, one above the other, of which that nearest the inferior face is the largest (*a*, fig. 1). Besides these the section contains eight other ribs, of which those of the superior face are the smallest. We have, however, examined leaves of other specimens in which the median part of the blade contained no less than twenty-four mestome bundles, two of which were imbedded in the colorless parenchyma.

Turning to the lateral parts of the blade (fig. 2), we observe a similar difference in the development of the mestome bundles and by comparing them with those of the keel, we may distinguish four different degrees of development. The midrib of the inferior face represents the largest mestome bundle. It is surrounded by colorless parenchyma, of which the inner layer forms a sheath all around the bundle, bordering on a thick-walled and perfectly closed mestome sheath. The leptome and the hadrome are well differentiated and separated from each other by a small layer of thick walled mestome parenchyma. This mestome bundle is not in connection with any layer of stereome. There is, however, a large group of this tissue developed in the keel itself, but this is, as shown in figure 1, separated from the mestome bundle by the colorless parenchyma.

The mestome bundles of second degree (*b*, fig. 1) are represented not only in the median but also in the lateral parts of the blade. They differ from the above described merely in their smaller size and by the fact that the parenchyma sheath is here interrupted by the stereome on the inferior face of the bundle. The superior face, on the contrary, shows a group of colorless parenchyma, which is very large in the keel, but much smaller in the lateral parts of the blade. The mestome bundles of third degree (*c*, fig. 1) are very small and contain very little hadrome and leptome; they have no thick walled mestome parenchyma. The parenchyma and mestome sheaths are, however, well developed, the first being interrupted by the adjoining group of stereome. As mentioned above, some of the leaves we have examined were much larger than those in question, and we have observed some bundles to be imbedded in the colorless parenchyma of the keel. One of these bundles is shown in fig. 10, and this represents the fourth degree of development. It has no distinctly differen-

tiated parenchyma sheath, while the mestome sheath is very well developed, perfectly closed, and thick walled as in all the other mestome bundles. There is only one vessel in this bundle and a small group of leptome. These small bundles were observed only in the keel, in the parenchymatic layers which connect the two surfaces of the keel with each other, bordering on the large lacunes (*L*, fig. 1).

In regard to the general distribution of these various forms of mestome bundles in the leaf-blade of Oryza, those of the third degree are the most numerous, while those of second degree are less so; these last constitute the very rough ribs, which are so prominent on the upper surface of the leaf.

The stereome has attained a large development in this grass, and forms layers above and below all the mestome bundles of the lateral parts of the blade; as we have seen in figure 1, there is no stereome on the inner side of those mestome bundles which are situated in the keel. The margins of the blade possess large isolated groups of this tissue.

The mesophyll shows very distinctly that form of cells which Haberlandt[2] has designated as "Armpallisadenzellen" (fig. 3), in which the cell wall shows deep foldings inwards. This form of tissue has been observed in representatives of widely separated families of the vascular plants, e. g. Anemone and several other Ranunculaceæ, Bambusa, Arundinaria and a few other Gramineæ, Sambucus, several Gymnospermæ, Filices, Equisetum, etc. Haberlandt has explained the physiological signification of this peculiar folding of the cell wall in this way, that thereby the inner surface of the cell becomes considerably enlarged so as to be able to give space for an increased number of chlorophyll-grains.

The mesophyll in Oryza forms isolated groups between the mestome bundles, and surrounds the large lacunes of the keel.

The colorless parenchyma is very well represented as we have already seen above from the description of the mestome bundles and their surroundings. We have discussed the colorless parenchyma sheath, the various groups of the same kind of tissue above the mestome bundles, and finally the large layers which divide the lacunes of the keel. A marked characteristic of Oryza is the structure of the keel, with its

[2] G. HABERLANDT: Physiologisches Pflanzenanatomie 174. Leipzig 1884.

numerous mestome bundles and large lacunes in which diaphragms are to be found (as shown in fig. 7), somewhat resembling those which characterize various species of Juncus.

Washington, D. C.

Explanation of Plates XXVII and XXVIII.

Figs. 1–10. Transverse sections of the leaf-blade of *Oryza sativa.*

Fig. 1. The median part, showing five mestome bundles on each face, those of the inferior face being the largest. The lacunes (*L*) are separated by narrow strata of colorless parenchyma. The mestome bundles *a*, *b*, *c*, represent respectively first, second and third degree of development. × 75.

Fig. 2. The lateral part of the blade; *J*, the inferior face; *S*, the superior. × 75.

Fig. 3. Chlorophyll-bearing cells of the mesophyll; the cell-wall showing deep foldings inward; *P*, cells of the parenchyma-sheath; *BC*, bulliform cells. × 320.

Fig. 4. Group of bulliform cells. × 320.

Fig. 5. Epidermis of the inferior face, *Ep*, with a part of a mestome bundle. × 320.

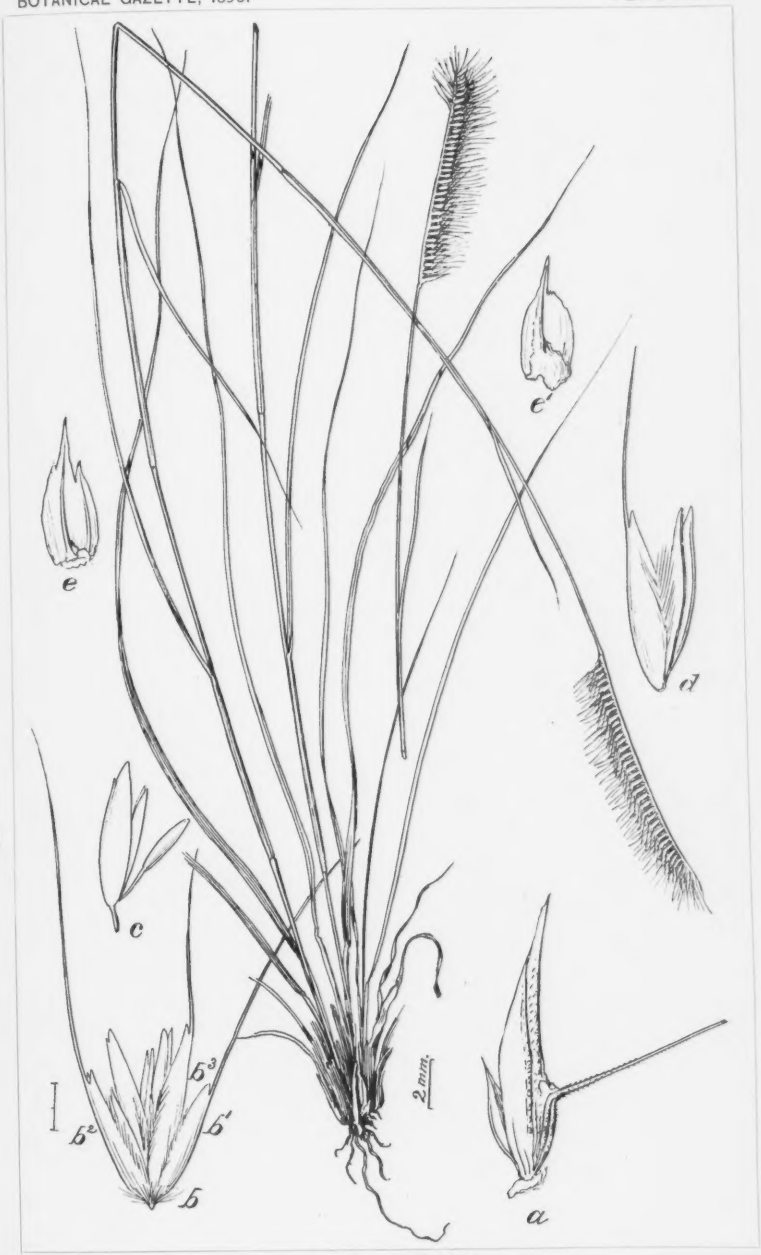
Fig. 6. Epidermis of the superior face, *Ep*, bordering on a group of stereome, *St*, and colorless parenchyma, *P*. × 320.

Fig. 7. Cells of a diaphragm from the lacunes. × 320.

Fig. 8. Part of the large dorsal mestome bundle from the keel. *Ep*, epidermis; *St*, stereome; *P*, colorless parenchyma; *MS*, mestome-sheath; *Lpt*, leptome; *V*, vessels. × 320.

Fig. 9. The median mestome bundle of the superior face of the blade. × 320.

Fig. 10. A very small mestome bundle, representing the fourth degree of development, from the colorless parenchyma of the keel. × 340.



SMITH on CTENIUM.

A synopsis of the American species of Ctenium.

JARED G. SMITH.

WITH PLATE XXIX.

Artificial key to the species.

1. Spikes 1 or 2 2
1. Spikes 3 to 6, awns of the third and fourth glumes three times as long as the glumes themselves . . . . . *C. polystachyum.*
2. Awn of the fourth glume nearly 2 inches, recurved. *C. cirrhosum.*
2. Awn of the fourth glume less than 1 inch, straight or simply divergent 3
3. Nerves of the second glume strongly tuberculate-roughened . 4
3. Nerves simply scabrous . . . . . *C. Chapadense.*
4. Awn of the fourth glume twice exceeding it 5
4. Awn about equaling or shorter than the fourth glume . . . 6
5. Fifth glume twice as long as its awn; spike 4 to 5 inches . . . . . *C. planifolium.*
5. Fifth glume equaling its awn; spikes 2 inches . *C. glandulosum.*
6. Awn of the fourth glume about equaling the glume itself . . 7
6. Awn of the fourth glume less than half as long as the glume itself . . . . . *C. brachystachyum.*
7. Spike 1½ inch long, awns slender . . . . . *C. brevispicatum.*
7. Spike 2½ to 5 inches long, awns stout . . . *C. Carolinianum.*

1. *Spikes three to six.*

CTENIUM POLYSTACHYUM Balansa Bull. Soc. Bot. de France **32:** 244. 1885.

Culms cespitose, two to four feet high; leaves pubescent; spikes three to six, digitate-paniculate; spikelets 4-flowered; third and fourth glumes 3-nerved, long-ciliate on the lateral nerves, the middle nerve prolonged into a scabrous awn three or more times the length of the glume; fifth glume keeled, ciliate only along the margin, 3-nerved.

Paraguay.

2. *Spikes one or two; awn of the fourth glume nearly two inches, recurved.*

CTENIUM CIRRHOSUM Kth. Rev. Gram. 445. *pl. 136.*
Campulosus cirrhosus Nees Agrost. Bras. 416.

Culms slender, cespitose, two to four feet high; leaves scabrous; spike one; first empty glume nearly as long as the spikelet; second empty glume much exceeding it; third glume with an awn twice as long as itself; fourth glume with a recurved awn nearly two inches long; fifth glume cuspidate or mucronate at the apex.

On high plains in southern Brazil.

3. *Spikes one or two; awn of the fourth glume one-half inch long or less.*

a. *Nerves of the second glume scabrous, not glandular-tuberculate.*

CTENIUM CHAPADENSE Doell. in Mart. Flor. Bras. 2^3: 73.
Campulosus Chapadensis Trin. Sp. Gram. *pl. 303.*

Culms slender, three feet high, basal leaves six to nine inches, those of the culm about four inches long, the uppermost shorter; spike one, terminal; first glume a little shorter than the spikelet; second glume twice exceeding it; third and fourth glumes ciliate, pilose at the base, with awns four or five times longer than themselves; fifth glume ciliate, naked at the base, longer than the third and fourth glume, with an awn a little longer than itself.

Florida to Argentina.

b. *Nerves of the second glume strongly glandular-tuberculate.*

Ctenium glandulosum Scribn. & Smith, sp. nov.—*Plate XXIX.*

Culmi 14–18 pollices longi, simplices, erecti, teretes, striati, scabri praesertim sub nodis, apice distincte striati pubescentes cum annulo hirsuto basi inflorescentiæ, nodis glabris; vaginæ striatæ internodis breviores; laminæ planæ, striatæ, glabræ, aut supra minute scabræ, lineares, 4–12 pollices longæ, 1–1.5 lineas latæ, apicem versus filiformes, summæ breviores, involutæ, setaceæ; spica unica pectinata, saepe 2 pollices longa, recta aut falcata subspiralis, rachis plana scabra; spiculæ patulæ biseriatæ dense imbricatæ; gluma vacua

prima obliqua linealis, basi tuberculato-crassa, 1-nervis, acuta interdum dentata; gluma vacua secunda 3 lineas longa, obliqua, lanceolata, trinervis, nervo medio in aristam scabram excurrente ex quarta basali glumæ, pulvino in axilla aristæ prominente, arista glumæ subaequali, nervis lateralibus glanduloso-tuberculatis per inferiorem bessem, scabris superne; gluma tertia vacua lanceolata acuta, sesquilinealis, arista duplo longiore, tenui, scabra, excurrente ex tertia summa glumæ, trinervis, marginibus albis ciliis cristatis basi dense barbata; gluma quarta cum palea neutra duas lineas excedens, lanceolata acuta, trinervata, marginibus medio pilis albis cristatis, semilinealis, arista dorso 4 lineas longa sub apice oriente; gluma quinta florens, duas lineas longa, arista 3 lineas longa, palea subaequilonga, apice bidentata 2-nervis, ciliatis; gluma sexta sterilis, glabra, brevipedicellata subapice mucronata sesquilinealis; gluma septima rudimentum, linearis, semilinealis, pedicella tenuissima.

This species is founded on no. 2814 Nelson, collected between Niltepec and Zanatepec, Oaxaca, July 15, 1895, at an altitude of 400 feet. It has the habit of the Brazilian *C. brevispicatum* nom. nov., but the details of the spikelets do not agree.

Ctenium brevispicatum, nom. nov.

Campulosus brachystachyus Trin. Sp. Gram. *pl. 302,* not Nees.

Culms cespitose, one to two feet high, distinctly pubescent above, glabrous at the nodes; leaves about a foot long, smooth and glabrous except on the slightly hispid margins; spikes one or two, digitate, from one and one-half to two inches long or longer; first empty glume one-fourth the length of the spikelet; second empty glume as long as the spikelet; third and fourth glumes pilose at the base and along the margins above, awned from below the apex, the awns about equaling the glumes; fifth glume densely villous on the margins above, the awn usually a little shorter than the glume.

Brazil.

CTENIUM BRACHYSTACHYUM Kth. Rev. Gram. 447. *pl. 137.*

Campulosus brachystachyus Nees Agrost. Bras. 417, not Trin. Spec. Gram. *pl. 302.*

Culms cespitose, very slender, glabrous, one and one-fourth to two feet high; culm leaves rigid, scabrous on both sides, four to five inches long; spike terminal, one and one-fourth to one and one half inch long; spikelets 5-flowered; first empty glume very much shorter than the spikelet; the second

nearly equaling it, third and fourth glumes densely clothed along the margins with long, strict, white hairs, scabrous towards the apex, the awns one-half as long as the glumes; fifth glume emarginate at the apex and mucronate-awned, clothed with long strict white hairs at the margin, its awn very short straight and scabrous.

Brazil.

CTENIUM PLANIFOLIUM Kth. Enum. Pl. **1**: 275.

Campulosus planifolius Presl. Rel. Haenk. 287.

Culms two to two and one-half feet high, scabrous, especially below the nodes; leaves scabrous on both sides; spike one, more than four inches long; first empty glume very much shorter than the spikelet; second empty glume nearly equaling the spikelet, 2-nerved, hirsute; third and fourth glumes pilose on the back and margins, the third with a straight awn as long as itself; the fourth with an awn twice as long as itself; fifth glume a little longer than the lower ones, hirsute on the back, the margins densely white-pilose, terminated with a straight scabrous awn half as long as itself.

Mexico.

CTENIUM CAROLINIANUM Panz. in Denkschr. Akad. Muench. **1813**: 311. 1814.

Ctenium Americanum Spreng. Syst. **1**: 274. 1825.

Aegilops aromatica Walt. Flor. Car. 249.

Campulosus aromaticus Scribn. Mem. Torr. Bot. Club **5**: 45.

Culms one and one-half to four and one-half feet high; leaves six to fourteen inches long, glabrous; spikes one or two, one and one-half to six inches long; first empty glume one-third as long as the second, which is about as long as the spikelet; third glume pilose at the base and along the margins, awned below the apex with a stout spreading awn shorter than the glume; fourth glume one-third longer than the third glume, pilose at the base and tufted-ciliate on the margin about the middle, awned below the bifid apex with a stout divergent awn about as long as the glume; fifth glume about as long as the fourth, similar to it, except for the much shorter and less spreading awn.

North Carolina along the coast to Alabama.

Department of Agriculture, Washington, D. C.

EXPLANATION OF PLATE XXIX.

Ctenium glandulosum Scribn. & Smith.—*a*, *e*, *e*, empty glumes.—*b*, florets: b^1, third glume; b^2, fourth glume; b^3, fifth glume.—*d*. Fifth glume and palea.—*c*. Sterile rudiments.

The rate and mode of growth of banana leaves.

WALTER MAXWELL.

The quick rate of growth of young banana trees is a matter of general observation. This unusual growth is, in itself, a subject of interest; and when viewed in comparison with the development of the sugar cane and other plants, and in the light of the general laws and conditions of vegetable growth, this great rapidity of development, by which it unfolds leaf after leaf, makes the banana a very conspicuous example, and it has led me to record data showing the daily increase in the length and substance of growing leaves.

The following observations were made upon banana trees growing in front of my veranda, which were planted in December. The data may appear to cover a large surface of paper; they were recorded, however, during the spare minutes around meal times, and may properly be called *a door step study.*

In the two first examples noted the young leaf was observed just as it emerged from its enclosure within the stem of the previously grown leaf, which mode of development it is instructive to watch. When fairly started, the length of the leaf was taken, and the measurement was repeated, at a given time, on each succeeding day, until the leaf was unfolded and full-grown.

The two following tables give the history of two leaves whose development was observed in the way explained. Observations were made upon no. 1 at 1 P. M., and upon no. 2 at 5:30 P. M. In all tables lengths are given in inches and temperatures in degrees Fahrenheit.

Leaf I.

Date.	Length of Leaf.	Daily Growth.	Mean Temp.	Wind.
Jan. 26	6.5	0.0	70.5	N. E.
27	9.5	3.0	71.5	N. E.-S.
28	14.5	5.0	74.0	S.
29	20.5	6.0	76.5	S.
30	25.25	4.75	70.0	N.-N. E.
31	29.5	4.25	71.0	N.-N. E.
Feb. 1	35.0	5.5	73.0	N. E.
2	36.0	1.0	73.5	E.-N. E.

Leaf II.

Date.	Length of Leaf.	Daily Growth.	Mean Temp.	Wind.
Feb. 1	6.0	0.0	73.0	N. E.
2	9.75	3.75	73.5	E.–N. E.
3	13.5	3.75	74.0	N. E.
4	18.5	5.0	73.0	"
5	25.25	6.75	72.5	"
6	32.0	6.75	71.0	"
7	38.0	6.0	71.0	"
8	41.0	3.0	70.5	"
9	41.5	.5	68.5	"

The same observations were continued during the development of two more leaves, but with these examples the measurements were recorded twice daily for the purpose of noting the relative proportions of the day and night growths. The divisions of time were from 7:30 A. M. to 5:30 P. M., giving a period of day growth of ten hours; and from 5:30 P. M. to 7:30 A. M., giving a night period of fourteen hours. The day period represents approximately the hours that the sun was above the horizon.

Leaf III.—Night.

Date.	Length of Leaf.	Night Growth.	Night Temp.	Wind.
Feb. 9	0.0	0.0	65	N. E.
10	5.75	.75	64	"
11	8.75	1.25	66	"
12	13.25	1.25	62	N.–N. E.
13	16.5	1.0	60	"
14	22.25	2.0	65	S.
15	28.0	1.5	61	S. E.
16	35.5	3.0	62	N. W.
17	41.5	1.0	62	W.–S. W.
18	45.25	.75	62	S.
19	47.0	.5	63	S. W.

Leaf III.—Day.

Date.	Length of Leaf.	Day Growth.	Day Temp.	Total Daily Growth.	Wind.
Feb. 9	5.0	0.0	76	0.0	N. E.
10	7.5	1.75	73	2.5	"
11	12.0	3.25	75	4.5	"
12	15.5	2.25	75	3.5	N.-N. E.
13	20.25	3.75	76	4.75	"
14	26.5	4.25	78	6.25	S.
15	32.5	4.5	76	6.0	S. E.
16	40.5	5.0	77	8.0	N. W.
17	44.5	3.0	78	4.0	W.-S. W.
18	46.5	1.25	79	2.0	S.
19	48.0	1.0	78	1.5	S. W.

Leaf IV.—Night.

Date.	Length of Leaf.	Night Growth.	Night Temp.	Wind.
Feb. 26	5.5	0.0	67	E.-N. E.
27	8.5	.75	72	S. W.
28	10.75	.75	71	E.-N. E.
29	13.5	1.0	67	S. W.
Mar. 1	16.5	1.25	67	S.
2	19.25	.75	65	S. W.
3	23.25	1.25	64	E.-W.
4	28.0	2.0	61	W.-S. W.
5	36.5	2.75	62	W.-S. W.
6	44.75	1.25	64	N.
7	48.5	.75	65	N. E.
8	50.5	.5	65	N. E.
9	52.75	.25	66	N. E.

Leaf IV.—Day.

Date.		Length of Leaf.	Day Growth.	Day Temp.	Total Daily Growth.	Wind.
Feb.	26	7.75	2.25	78	0.0	E.–N. E.
	27	10.0	1.5	78	2.25	S. W.
	28	12.5	1.75	80	2.5	E.–N. E.
	29	15.25	1.75	80	2.75	S. W.
Mar.	1	18.5	2.0	81	3.75	S.
	2	22.0	2.75	77	3.5	S. W.
	3	26.0	2.75	72	4.0	E.–W.
	4	33.75	5.75	78	7.75	W.–S. W.
	5	42.0	5.5	80	8.25	W.–S. W.
	6	47.75	3.5	77	5.75	N.
	7	50.0	1.5	76	2.25	N. E.
	8	52.5	2.0	77	2.5	N. E.
	9	53.25	.5	76	.75	N. E.

Before speaking in detail of the data presented by the four tables giving the history of each leaf, for convenience, we shall bring these data together in a table of averages, in which are given the length, breadth, and surface development of the leaves, with the more detailed data. The "length of leaf" given is the total length of the mature leaf, less its length at the time of the first measurement. This correction is necessary, or the total "surface of the mature leaf," and the "daily surface growth" would be given too high.

The averages are as follows:

No. of Leaf.	Length of Leaf.	Breadth of Leaf.	Surface of Leaf. Sq. in.	Mean Growth of Day Period.	Mean Growth of Night Period.	Mean Daily Growth.	Mean Daily Surface Growth. Sq. in.	Mean Temp. of Growth.
No. I.	29.5	14	413	...	...	4.25	59.0	72.5
II.	35.5	14	497	...	...	4.5	62.0	72.0
III.	43.0	15	645	3.0	1.33	4.33	64.5	70.0
IV.	47.5	17	803	2.6	1.2	3.8	66.9	71.7

The first thing to which attention is called in this table is the mode of development. In the first place, a striking uniformity of growth is noted, and at the same time a gradual increase in the tree's capacity of assimilation, which is shown by the gradual increase in the "mean daily surface growth" from leaf I up to IV. I will state that these observations were made on one banana tree only, in order to exclude individual errors arising from the differences in individual trees, and that the four leaves were developed one after the other. This statement enables me to explain that the gradual increase in the daily surface growth from I to IV is due to the increasing area of assimilating surface. Each succeeding leaf has the last additional one to assist in gathering food for its growth, and the work goes more rapidly.

The increase in the rate of assimilation with the addition of new leaves is less than I expected to find. It is not in any way proportional to the increase of leaf surface; and this suggests that the chief burden in the work of making the next new leaf lies upon the previous leaf that was made. This is also further suggested by the banana tree's mode of growth. The banana appears to have only one center of growth and elaboration; it makes only one leaf at a time, and practically completes one leaf before it begins with the next. Many other trees are producing scores of leaves at the same time, showing that centers of work are distributed over the tree's complete organism. Moreover, the full grown leaves of the banana are soon frayed out with the wind and rendered useless for work, which forces the work of assimilation upon the new leaves. The details in the tables also show strikingly the variation in the rate of growth along the period of development. The young leaf begins slowly, daily increasing its rate of increase up to the stage of its maximum power of growth, where it tarries for two or more days, until the leaf, which hitherto has been almost as tightly rolled up as a cigar, begins to unfold to the light, when the rate of growth falls off till it is full grown. In the history of the four leaves this mode of growth is seen to obtain.

One other striking truth set forth by the daily data of development is the difference between the growths of the "day" and "night" periods. The observations were continued upon leaves III and IV not only to compare the results of the day and night growths, but also to note the results of variations

of temperature. The mean night growth of leaves III and IV was 1.25 inch, and the mean daily growth was 2.8 inch, which shows that about 70 per cent. of the total growth took place during the day, between 7:30 A. M. and 5:30 P. M. It also illustrates the effect of length of day.

The effect produced by variations of either day or night temperatures it is not easy to decide. In leaf I, for example, it is strongly indicated that the sudden and great fall of temperature on Jan. 30th, continuing over Jan. 31st, caused a decrease in the growth of the leaf. In the other examples, such as IV, a small fall in the night temperature, as on March 4th, does not at all interfere with the maximum growth. From this it appears that a great lowering of the temperature is necessary to seriously arrest progressive growth.

I am of opinion that the action of direct sunlight, and the direction and force of the wind, are more potent factors in increasing or arresting growth than small variations of temperature. On this subject I have, at present, no conclusive data.

The banana is an excellent subject in which to study given features of physiological development. The growth of its leaves is so rapid that measurements can be recorded twice daily with a measuring rule, and with the possibility of extremely small error. This is of great value in affording light upon the laws and conditions affecting the growth of other plants. The sugar cane, for example, grows so comparatively slowly that with it such observations as I have recorded are not possible. It will probably not be far wrong, however, if the data obtained in observing the banana are applied in judging of the influences which affect the growth of cane and other plants.

Hawaiian Experiment Station, Honolulu, H. I.

Noteworthy anatomical and physiological researches.

Researches on Drosophyllum lusitanicum.

A contribution on the vexed question of the nutrition of insectivorous plants is made by A. Dewèvre.[1] He has endeavored to ascertain whether the insects caught are really digested by a secretion from the plant as contended by Hooker, Darwin, Penzig and Goebel or whether bacteria digest them, the plant merely absorbing the products formed, according to the views of R. Dubois and Tischutkin.

After an anatomical and physiological investigation of the plant, the author concludes in spite of a number of negative results that absorption of proteids does take place; the absorption of carbohydrates is doubtful. Concerning the method of absorption the author ventures no statements.

The stem of Drosophyllum is very well developed, and the plant is perfectly well able to dispense with the nitrogen supply furnished by its captures. Moreover, the anatomical structure of the glands, both of the sessile and of the pedicellate types found, is not in harmony with the function of absorption. Since the supply of albuminous substances at the lower surface of the leaf would be more detrimental than beneficial, the author is inclined to question any connection whatever between the nutritive function and the mucilaginous, peptone-containing secretion formed by the glands in question.

When the inability to prove the absorption of the mucilaginous substance is taken into account, it is necessary to ascribe to this secretion another rôle. The author regards it as protective. By reason of its viscosity, this mucilage holds the insects that come in contact with it, kills them in a short time, then by the action of the pepsin which it contains, dissolves them and thus frees the leaf of them. In connection with the lower organisms, this protective function is still more marked. The entrance of bacteria and of spores of fungi into the interior tissues of this plant would result in serious consequences. The glands and their secretions prevent this since spores of fungi were found not to grow in this mucilage.—RODNEY H. TRUE.

[1] Annales des Sci. Nat. Bot. VIII. **2**: 19. 1896.

The root-hairs of Coniferæ.

Dr. C. von Tubeuf closes a series of papers entitled, "Die Haarbildungen der Coniferen" in *Forstlich-naturwissenschaftliche Zeitschrift* with an account of the root-hairs of the Coniferæ,[1] of which the following is an abstract.

Of the root-hairs of Coniferæ little is known. In the few instances in which they have been observed they have been considered functionless. Schwarz found among all the species of Pinus and Abies observed, only Abies obovata sometimes with very short hairs which could scarcely be of any importance in absorbing water.

Strasburger states[2] that root-hairs are entirely wanting in species of Thuja, Sequoia, and Araucaria; are present exceptionally in Ephedra, sparingly in Pinus spp., and abundantly only in Taxus.

But von Tubeuf finds twenty-four species capable at least of producing root-hairs, and though no root-hairs were found on seven species he thinks it not certain that these species do not, at other times or under other conditions, form root-hairs.

On firs (Picea excelsa) three to six years old, few or no hairs were found between Feb. 28th and May 28th, but by June 28th the many young rootlets were clothed with many hairs which were present up to Nov. 28th.

The shape of the hairs is very various. In the Abietineæ they are always very long filaments and arise at a considerable distance from the tip of the root and from the second or third layer of the cortex, breaking through the outer cells, which slough off. Among the Taxaceæ, only Ginkgo has long thin-walled filamentous hairs. Taxus has very short rigid hairs whose walls are finely papillose. The hairs of Torreya and Cephalotaxus, having a very broad base, are mostly conical and very numerous, arising close behind the root tip.

The function of the root-hairs appears to be that of these structures elsewhere, viz.: to increase the surface by which water and food materials are absorbed. Frank combats the idea that they can suffice for this work and thinks that it is properly accomplished only when fungi (which he calls "Baumammen") invest the lateral roots as a mycorhiza. From

[1] Forstl.-naturwiss. Zeits. **5**: 173–193. *pls. 3.* My 1896.
[2] Coniferen u. Gnetaceen 343.

his *Lehrbuch der Botanik* it is not apparent that the Coniferæ form any root-hairs but one is left to infer that they are supplied exclusively through the fungi. Indeed he says (op. cit. 259) that mycorhiza is a constant phenomenon in all forest trees of Cupuliferæ, Betulaceæ and Coniferæ; that this symbiosis has been found everywhere it has been sought, in all sorts of soils; that the fungus is present from the first year of the tree throughout its life upon all the absorbing roots; that the entire absence of root-hairs is a striking peculiarity of mycorhiza; and that the tree receives water and food materials only through the mycorhiza fungus. These statements are repeated essentially in his "Die Krankheiten der Pflanzen" (1895) and are much more radical than his earlier ones, in which he speaks of root-hairs of pines as normal in humus-free soils while mycorhiza generally appears in humus soils. In all his publications he recognizes only one form of mycorhiza which he calls the ectotrophic.

But Sarauw in 1893 had found intracellular mycelium in Cedrus and in Taxus. Von Tubeuf, also investigating numerous conifers in all situations, has discovered that an intracellular mycelium occurs very commonly among the living cells of the cortex in many species of certain families so that Frank's *endotrophic* mycorhiza has an unexpectedly wide distribution.

In all Abietineæ, and in this family alone, ectotrophic mycorhiza may occur either (a) as a purely external jacket, or (b) as a jacket sending hyphæ into the intercellular spaces of the cortex, or (c) as an intracellular mycelium only, with root-hairs. It was found that all Abietineæ are capable of producing root-hairs *at the same time*. Endotrophic mycorhiza occurs in very many conifers of other families, agreeing neither with Frank's ericaceous nor orchidaceous types, but constituting a coniferous type, characterized by having the mycelium in a deep-seated zone of the cortical cells, the outer ones being free from it, and without special connection with the outer hyphæ as is the case in ectotrophic mycorhiza. It does not affect the formation of root-hairs, which are often luxuriantly developed on mycorhizal roots. The abundance of the hairs suggests that they are functional and experiments demonstrated this. Plants were cultivated in sterilized soils with artificial fertilizers; they developed normally, produced abundant root-hairs and grew vigorously for two years.—R.

BRIEFER ARTICLES.

A remarkable macrospore.—In recent literature references to Treub's "*Casuarina*"[1] are becoming quite frequent, and deservedly so, for *Casuarina* is a remarkable plant and the monograph gives the results of extensive investigations. The account of chalazogamy alone would make the paper a classic, but the peculiarities in the embryo-sac seem to merit equal attention. Treub says that the embryo-sac of *Casuarina* contains a sex-apparatus normally composed of two or three cells which seem to be derived from a single mother cell, yet the author claims that the cells associated with the oosphere are not synergidæ, but have an entirely different origin. The assertion is also made that in *Casuarina* no antipodal cells are formed. The lack of a secondary nucleus formed by the fusion of two polar nuclei is another exceptional feature, while the formation of endosperm and also the formation of cell walls around the oosphere and other cells of the sex-apparatus before fertilization complete a list of striking variations from the normal angiosperm type.

I have been deeply interested in Casuarina's embryo-sac without antipodals, as I have been studying *Salix*, and for more than a year was unable to discover any trace of antipodals. However, *Salix* has antipodals, as some of my preparations now prove. Some slides also show the fusion of polar nuclei to form the endosperm nucleus. There is no doubt that the antipodals of *Salix* are exceedingly transitory but they are formed nevertheless. It may be that *Casuarina* has antipodals of this evanescent character. Since the technique betrayed by Treub's figures and text could be greatly improved, I should be glad to see the Casuarina sac studied again and in much greater detail, in order that Treub's conclusions may receive additional confirmation or be corrected.—CHAS. CHAMBERLAIN, *University of Chicago.*

Aster tardiflorus: a correction.—My attention has been called to a clerical error in my paper on *Aster tardiflorus* in the preceding number of the GAZETTE. On page 275, in the last clause of the first paragraph, the words "inner" and "outer" should be transposed; and the clause should read: the outer scales of the imbricated involucre longer than the inner. The error originally arose through mistaking the phrase "*inferioribus longioribus*" for *interioribus longioribus*.—MERRITT LYNDON FERNALD, *Cambridge, Mass.*

[1] Sur les Casuarinées et leur place dans le systeme naturel. Ann. Jard. Buit. **10:** —. —.

CURRENT LITERATURE.

Essentials of Botany.[1]

WHEN Professor Bessey began to publish his text-books the botanical instructors of the United States were teaching chiefly the gross morphology and classification of "flowering plants" as presented by Gray's fascinating text and manual. A larger view of plants had taken possession of Germany, and this view Professor Bessey sought to transplant. How well he succeeded is witnessed by the revolution that followed in American botanical teaching, especially in the colleges. The ready response, the adoption of real laboratory methods, the multiplication of texts and laboratory guides on the new basis, all show how great was the need. Among all the American books, however, which belong to the new dispensation, those of Professor Bessey fairly stand as the pioneers. His very large and successful experience as a teacher has peculiarly fitted him for the work, and has enabled him to organize the text and touch the needs in a way quite beyond the comprehension of the mere investigator.

It is with great pleasure that we welcome the new edition of his very useful "Essentials," for the rapid advance of the science had left the old one inadequate in many important particulars, which the author appreciated more keenly than any one. As the book has been and must continue to be one of the most largely used texts it is to the interest of botany for it to present current views. The most notable change is to be found in the new chapter on plant physiology, a subject which has been made a science since the old text was written. Protoplasm and the cell-structures are also freshly presented in the light of new knowledge. In the matter of classification, Professor Bessey has his own views, presented to the botanical public before, and now in his new book. His rejection of the slime-moulds as plants, and his similar but not so positive disposition of *Pandorina* and *Volvox*, may simplify classification, but probably will not satisfy botanists. The breaking up of Thallophyta into three great groups (Protophyta, Phycophyta and Carpophyta) coordinate with Bryophyta, etc., and the submergence of the well known categories Algæ and Fungi, is a view which will have to fight its way, but has undoubtedly the merit of easy presentation to beginners. We wish that

[1] BESSEY, CHARLES E.—The Essentials of Botany. Sixth Edition, revised and enlarged. 1896. New York: Henry Holt & Co.

Professor Bessey had abandoned the term "Anthophyta," as but little more appropriate than "Phanerogamia," and adopted the really significant term "Spermatophyta" (too often written "Spermaphyta"); and that his popular name "flowering plants" had been changed to "seed-plants."

In the presentation of the angiosperms Professor Bessey follows neither the grouping and sequence of Bentham and Hooker, nor of Engler and Prantl, but has formulated one of his own. That the presentation of Bentham and Hooker should be abandoned is clear; but those of Engler and Prantl, and of this book are based upon opposite propositions which the morphology of the future must settle. Bessey's proposition that "in the primitive flower all the parts were separate" coincides with the Engler position as far as it goes. But Bessey's "primitive flower" has some or all the parts in a cyclic arrangement, and then calls for the reduction process to produce the simpler flowers. Engler, on the contrary, sees in these simpler flowers not reduced forms but primitive forms; his primitive flowers having free parts, to be sure, but these parts spirally arranged and consequently indefinite in number, the cyclic arrangement and hence definite numbers appearing later. Whether the so-called "simpler flowers" are so because of reduction or because they are primitive is as yet largely a matter of opinion, and Professor Bessey has chosen the former alternative.

But such a discussion leads us far away from the purpose of the book before us, which is certainly an effective recasting of a long-tried and very useful text.

Citrous fruits.

MESSRS. W. T. SWINGLE AND H. J. WEBBER, of the Division of Vegetable Physiology and Pathology, Department of Agriculture, have been working for three years in the subtropical laboratory at Eustis, Florida, upon the diseases of citrous fruits. Bulletin no. 8 has just been issued from the Division, giving for the first time the results of their work upon the principal diseases. Six diseases are presented: blight, die-back or exanthema, scab or verrucosis, sooty mold, foot-rot or mal-di-gomma, and melanose. In each case the symptoms, cause, and treatment are described, illustrated by eight plates, three of them colored. While much of the Bulletin deserves reprinting and wide attention, the following outline from the summary may indicate a few of the results:

1. *Blight:* Attacks trees only when over five years old and in bearing, causing sudden wilting of the leaves; in the spring after the top

wilts the branches bloom profusely, but the flowers are small and almost never set fruit; the affected trees may linger for many years, and rarely die outright; the annual loss from this disease in Florida is about $150,000; the cause is unknown, but it is probably a contagious malady and incurable; affected trees should be dug up and burned.

2. *Die-back* or *exanthema:* Caused by malnutrition, accompanied by improper drainage, improper cultivation, etc.; recognized by the very large dark pointed leaves and the reddish-brown stains on certain of the new-growth twigs, which later die back; brown eruptions occur abundantly on young and old twigs, all of which finally die back; multiple buds form in the leaf axils; diseased trees bear little fruit, which is off color and commonly disfigured by the reddish-brown stain; annual loss from the disease in Florida about $100,000; withholding all organic nitrogenous manures, ceasing to cultivate, and mulching the soil have been found beneficial.

3. *Scab* or *verrucosis:* Attacks principally sour oranges and lemons, the common sweet orange being exempt; probably introduced into America from Japan; shows as small excrescences on young leaves and fruit, at first pale, but soon coated with a dusky growth of *Cladosporium*, the parasite causing the disease; very much distorts young leaves and the fruits; loss chiefly from action on lemons, causing an annual loss in Florida of about $50,000; prevented on lemons by spraying young fruits from three to five times with ammoniacal solution of copper carbonate.

4. *Sooty mold:* A black fungus, which follows the attacks of certain honeydew-secreting insects; recognized by the sooty black membrane formed principally over upper surfaces of leaves, fruits, and stems; greatly reduces productivity of trees, and the oranges formed are badly disfigured; annual loss in Florida from the disease about $50,000; spraying with resin wash has been found very effective, also fumigation with hydrocyanic acid gas; a parasite fungus (*Aschersonia tahitensis*) promises to be a very great aid in combating the malady.

5. *Foot rot* or *mal-di-gomma:* The most widespread of all orange diseases; recognized by exudation of gum from patches on the tree near the base, resulting in falling off of the bark; spreads down the roots and around the trunk, the tree often being girdled and killed; apparently contagious and caused by some minute organism; the sour orange almost exempt, and disease may be prevented by using sour orange stocks on lowlands and flat woods, and grape fruit stocks on high and dry pine lands; removing soil from around the crown roots the most effective treatment; annual loss from the disease in Florida about $100,000.

6. *Melanose:* A new disease, not yet causing much damage in Florida, probably only about $5,000 in 1894; forms minute brown spots on leaves, twigs, and fruits, greatly staining and disfiguring the fruit; cause not certainly known, but probably some parasitic fungus; very effective remedy is the application of Bordeaux mixture or ammoniacal solution of copper carbonate to the young fruits.

A manual on the food of plants.

Elementary guides to simple laboratory practice, constructed upon approved methods, are not yet numerous, and must be always welcome. In many respects the little pocket manual on the food of plants, prepared by A. P. Laurie,[1] is a model. It is arranged in a strictly logical sequence, is inductive in method, and brings the subject within the apprehension of the beginner. The aim of the work is to show the elementary composition of plants, the source of food supply and to some extent the manner in which plants obtain their food. The author seems to think that this leads, as a matter of course, to agricultural chemistry, but on the contrary it is quite as good an introduction to vegetable physiology, or even better. The work was written for use in Great Britain; and in many parts of the United States and Canada the chapter on the derivation of soils from primitive rock would need modification to apply to the drift region.

The work consists of thirty-three simple laboratory experiments with only enough text to bind them together. They would be most excellent for high school work, or any elementary course where pupils are under the guidance of a teacher.

Minor Notices.

A SMALL WORK on vegetable culture, by Alexander Dean,[2] has come to us for notice. It is a concise manual for pactical instructions for raising the vegetables in ordinary use in Great Britain, but is not specially applicable to the conditions and requirements in America. It will interest those who are curious about the methods of English culinary gardening, as the work is well written.

THE WORK of Arthur and Bolley on *Bacteriosis of Carnations*, issued as bulletin 59 of Purdue University, deserves more than the pass-

[1] LAURIE, A. P.—The food of plants: an introduction to agricultural chemistry. London and New York, Macmillan & Co. 1893. 16mo. pp. ix+77. Illustrated.

[2] DEAN, ALEXANDER.—Vegetable culture: a primer for amateurs, cottagers, and allotment-holders. Edited by J. Wright. London and New York, Macmillan & Co., 1896. 16mo. pp. 136. 38 illust. in text. 35 cents.

ing notice on p. 252 which the senior author gave it. Although preliminary notices of this work have been given in various places, the full paper is now published for the first time with adequate illustrations and is particularly important as making known the symptoms, nature, and preventive treatment of another bacterial disease. The disease was discovered by Dr. Arthur in 1887–8. In January, 1889, Mr. Bolley's work began and continued for about a year and a half, since which time Dr. Arthur has continued the investigation.

Bacteriosis is a widespread disease of carnations, affecting primarily the leaves, thereby checking growth and productiveness. It is caused by a parasitic bacterium, entering the plant from the air through stomata or the punctures of aphides, which has been isolated and described as a new species, *Bacterium Dianthi.* The disease shows itself first by producing minute translucent yellowish spots, visible when the leaf is looked at against a strong light. These spread and the leaf finally withers and dries up. Other pinks may be artificially infected but the chief damage is to carnations, especially old and weak or poorly grown plants. It may be almost wholly prevented by keeping the foliage dry and free from aphides. Wire netting bent into Λ-shape and placed between the rows of plants supports the foliage and permits proper watering without wetting the leaves. Overhead spraying should be done occasionally on bright days with water containing a small amount of ammoniacal copper carbonate.

The paper is illustrated by eight plates, of which two are remarkably fine chromolithographs. The four drawn by Mr. Bolley are rather crude. Two others are half-tones, showing proper methods of growing in houses at Lafayette, Ind., and Queens, N. Y.

NOTES AND NEWS.

MR. WM. L. BRAY sails for Berlin about the middle of July to be abroad a year.

DR. VICTOR SCHIFFNER has been called to the professorship of systematic botany at the German University of Prague.

A LIST of the orchids grown in the Botanic Gardens of Jamaica is given in the *Bulletin of the Bot. Dept. Jamaica*, for April. It numbers 256 species belonging to eighty-one genera.

THE BOTANISTS of Vermont have organized what seems to be a very vigorous state botanical club, which held its first winter meeting last February at the Museum of the University of Vermont.

PROFS. J. C. ARTHUR and D. T. MacDougal sailed for Europe early in June. Dr. Arthur will spend the summer at Bonn with Strasburger and Prof. MacDougal at Tübingen with Vöchting.

MR. T. D. A. COCKERELL has announced the proposed establishment of a biological station in New Mexico, as a "health and holiday resort for scientific persons." He may be addressed at Las Cruces, New Mexico.

PROFESSOR E. L. GREENE, in *Pittonia* (May 16), has given a history of *Viola pedata*, var. *bicolor;* showing that the variety is really the *V. pedata* L., and that the *V. pedata* of American authors was a form discovered much later, for which he proposes the name var. *inornata*.

DR. N. L. BRITTON, professor of botany in Columbia University has been appointed director of the New York Botanical Garden, and the place so made vacant has been filled by the appointment of Dr. Lucien M. Underwood, now professor of botany in Alabama Polytechnic Institute.

PROF. W. WHITMAN BAILEY has been appointed by President Cleveland a member of the Board of Visitors to the West Point Military Academy. Prof. Bailey was born at West Point in 1843, the youngest son of Prof. J. W. Bailey the microscopist, who was a graduate of the Academy.

AN ILLUSTRATION of *Erythronium Johnsoni* Bolander, of the Coast Ranges of southern Oregon, is published in *The Gardeners' Chronicle* (May 2). In the same number the fertile cones of the African *Sequoia* (*Wellingtonia*) *gigantea* and the Californian *S. sempervirens* are illustrated, showing also individual bracts and ovules.

THE UNIVERSITY OF WISCONSIN at its summer school, July 6th–August 14th, offers laboratory courses in the physiology of plants and in general morphology of plants, both with special reference to the adaptation of the work to the high school. Special courses can also be arranged by advanced students. The work is under the direction of Prof. C. R. Barnes.

MR. C. G. LLOYD of Cincinnati, Ohio, has distributed a list of 243 fleshy and woody fungi added to his mycological museum during 1895. Mr. Lloyd is so generous in loaning his books and specimens to students, and in other ways, that his request for donations of the larger fungi, especially of such as preserve their characters when dried, should meet with a hearty response from collectors.

A *Flora of the Alps*, intended especially for English visitors, is announced for the spring of 1896, from the hand of Mr. Alfred W. Bennett, lecturer on botany at St. Thomas's Hospital, London. It is to form two octavo volumes, with 120 colored plates—not exactly a handy size, one would think, for tourists. The *Flora* will of course include many alpine plants of the adjacent mountain districts of France, Italy, and Austria.

THE NEXT VOLUME in the "Rural Science Series" will probably be Professor Bailey's monograph of *The Apple*. The work is to comprise two parts, the first treating of all the practical matters of apple-growing, and the second of such scientific matters as the botany of the apple, its history and evolution, production of new varieties, and the like. It is expected the work will be completed and ready for publication in the fall.—*Book Reviews.*

THE "Roentgen rays" are compared, in *Gardeners' Chronicle* (May 2), "with the feeble but very penetrating light given out by phosphorescent fungi." Mr. W. G. Smith records having seen the light of phosphorescent mycelia "penetrating several thicknesses of packing paper." In 1875 he "recorded the light as having been distinctly seen through two thicknesses of writing paper;" while in 1872 "the Rev. M. J. Berkeley has recorded an instance of the phosphorescent light from fungi penetrating through five thicknesses of paper, the light penetrating through all the folds on either side of the example, as if the specimen was exposed."

WE ARE INFORMED by M. Cardot that he intends sending to the National Herbarium the original types of most of the American new species of mosses already described by Renauld and himself. He also promises that in the future, whenever it is possible, a type of each new species described will be deposited in this herbarium in order that it may be readily accessible to American bryologists. We take the liberty of expressing the thanks of the students of our moss flora to MM. Renauld and Cardot, for this action, which we are sure will be highly appreciated. We wish the custom might spread among all foreigners who describe new species in any group from this country.

THE BOTANICAL COURSES offered at the summer school of the University of Pennsylvania, beginning July 6th, are as follows:

Ten lectures on "The evolution and distribution of flowering plants," by Dr. Benjamin L. Robinson of Harvard University; two lectures by Dr. John M. Macfarlane of the University of Pennsylvania, on "Timber trees in health," and "Timber trees in decay;" Five lectures on "The natural history of field and garden plants," by Dr. J. W. Harshberger of the University of Pennsylvania; five lectures on "Natural products," by Professor William P. Wilson of the Philadelphia Museums; five lectures on "Fungous diseases of plants," by Professor Byron D. Halsted, of Rutgers College.

ARTICLES of taxonomic interest in the *Journal of Botany* for May are as follows: Cape algæ, illustrated, by Ethel S. Barton; some new Polygalas from Africa, by Dr. R. Chodat; a continuation of Wainio's account of the Elliott collection of lichens from the Antilles, including numerous new species; a revision of the species of *Rosa* of the Babington herbarium, by Francois Crépin, which would serve its purpose better if translated; another fascicle of the never ending British Rubi, by Rev. Augustin Ley; several new species of African *Cyperaceæ;* and an interesting little nomenclature discussion in which our good friend the editor finds himself involved, and which must remind him of some of the strictures he has put upon our American Britton.

PROFESSOR GEORGE F. ATKINSON has been experimenting upon species of *Onoclea*, and showing "that the sporophylls can be made to assume the form and function of the foliar organs by cutting off the latter, thus disturbing the nutrition and forcing the vegetation function on the sporophylls." These results are the occasion of a paper on "The probable influence of disturbed nutrition (carbon-assimilation) on the evolution of the vegetative phase of the sporophyte," printed in *Amer. Nat.* (May), a very suggestive discussion; in which Bower's hypothesis as to the primary character of sporophylls as compared with foliage leaves is sustained, and the influence suggested by means of which carbon-assimilation was gradually transferred from the gametophyte to the sporophyte.

THE CURRENT NUMBER of *Acta Horti Petropolitani* (Vol. XIV. no. 1) contains the following papers: The Potentillas of Central Russia, by A. Petunnikov, illustrated by eleven plates, in which a full discussion of the forms and their natural relationships is given, suggesting bases of classification different from those current; a revision of the genus *Carpesium* (Compositæ), by C. Winkler; an enumeration of plants collected in the mountains of China by Putjata and Bovodowsky in 1891, by J. Palibin, among which are several new species, and the whole list bearing a North American aspect; some new Asiatic Compositæ, among which *Senecio* predominates, by C. Winkler; and notes concerning Asiatic plants, by A. Batalin, in which there are several new species and varieties of *Prunus* and *Lonicera*, and a synopsis of the species of *Dipelta* and *Incarvillea*.

THE LATEST STUDIES among North American plants, as recorded in *Bull. Torr. Bot. Club* (April), are as follows: a provisional list of the species of *Kuhnistera* (*Petalostemon*), by A. A. Heller, giving synonymy and range, and including the description of a new southern species, *K. Gattingeri;* further studies of our southeastern plants, by John K. Small, including a new *Portulaca* and a new *Nymphæa*, and disentangling *Hibiscus lasiocarpus* and *H. grandiflorus;* another presentation of the much discussed forms of *Sisyrinchium* of E. U. S., by Eugene P. Bicknell, reaching the conclusion that there are three species, *S. graminoides* (first printed *gramnoides*, a new name given to the *S. Bermudianum* of Amer. authors, and the *S. anceps* of Watson in Gray's Manual, no old name being available), *S. Atlanticum* (a new species),

and *S. angustifolium* Miller; notes on *Meibomia* (*Desmodium*), by Anna Murray Vail; some new and interesting grasses, by F. Lamson-Scribner, and others by Geo. V. Nash.

THE RELATION between calcium and the conduction of carbohydrates has been a subject of investigation by Mr. Percy Groom, who publishes his results in *Annals of Botany* (March). His summary is as follows:

"(1) Acid potassic oxalate retards the action of diastase on starch.

(2) In the living plant the first, and, at the commencement, the only visible effect of acid potassic oxalate on the assimilating organs is the accumulation of starch, owing to an arrest of the change of the starch into sugar.

(3) The second effect, as the soluble oxalate accumulates, is a retardation of the manufacture of starch, and hence probably of the assimilation of carbon.

(4) The last effect, with increased accumulation of the oxalate, is the death of the protoplasm."

All of which indicates that the lack of calcium permits this injurious accumulation of acid potassic oxalate, which otherwise would be neutralized by the manufacture of calcium oxalate.

MACMILLAN & CO. will publish immediately an entirely new edition of *The Nursery Book*, thoroughly recast and revised by the author, Professor L. H. Bailey, of Cornell University. This little manual has been one of the most popular of all current horticultural books and has found a wide circulation both amongst nurserymen and amateurs. Many new illustrations have been made for this edition, bringing the number of cuts up to over 150. It is one of the Garden Craft Series.

The Pruning Book, now in preparation by the same author, will be the next volume in this series. Professor Bailey has been making definite experiments and observations upon this subject for a number of years, and the results of these labors are now approaching readiness for publication. An artist is now employed, under Professor Bailey's direction, in making illustrations for the book which will comprise the entire range of the theory and practice of pruning, both of fruit and ornamental trees and shrubs. It is expected to be on sale early in 1897 or before.

Macmillan & Co. also announce for early publication volume I of the Columbia University Botanical Series, entitled *Elementary Botany*, by Dr. Carlton C. Curtis, tutor in botany, Columbia University, with an introduction by Dr. N. L. Britton.

THE HOPKINS SEASIDE LABORATORY of the Leland Stanford Junior University, founded by Mr. Timothy Hopkins in 1892, opens its fifth session Monday, June 15, 1896. The regular course of instruction will continue six weeks, closing July 25th. Investigators and students working without instruction may continue their work through the summer.

The laboratory provides opportunities for investigators who are prepared to carry on researches in morphology or physiology; for students in the departments of zoology and botany in the university, who wish to supplement their work under the favorable conditions of

such an institution, and to gain a knowledge of the methods of research in biology; and for students and teachers not members of the university, who desire to pursue biological studies and to become acquainted with the practical methods of laboratory work. For the latter regular courses are conducted in zoology and botany, accompanied by lectures and by individual instruction at the work table.

The instructor in botany is Mr. Walter R. Shaw.

The laboratory is located on a low bluff immediately overlooking the beach at Pacific Grove, a seaside resort on the southern shore of Monterey Bay, two miles west of Monterey. In the immediate vicinity of the laboratory are exceptionally fine collecting grounds. To investigators prepared to carry on original work the use of the laboratory and its equipment is tendered free of charge. Other students pay a moderate fee for the term of six weeks.

The course in botany consists mainly of a comparative study of the principal groups of fresh water and marine algæ, with collateral work in other groups of plants.

THE FOLLOWING STATEMENT concerning the herbarium and botanical library of Columbia University is of general botanical interest. It is taken from the announcement of the "School of Pure Science," just issued.

The herbarium contains about 500,000 specimens, being one of the largest in America; additions are at present made to it at the rate of about 20,000 specimens a year. It comprises: (1) The collections accumulated by Dr. Torrey, which came into the possession of the university at his death in 1873. (2) The collections of Professor C. F. Meisner of Basle, Switzerland, presented to the university about the time of Dr. Torrey's death, by Mr. John J. Crooke. (3) The collections of Dr. A. W. Chapman of Appalachicola, Florida, presented by Mr. Crooke at the same time, containing the types illustrating Dr. Chapman's Flora of the southern United States. (4) The mosses of the late C. F. Austin. (5) The mosses of the late Dr. J. G. Jaeger, recently acquired. (6) Miscellaneous accumulations since Dr. Torrey's death, now making up more than one-third of the whole collection. The herbarium is rich in types of species described by Dr. Torrey, Professer Meisner, Dr. Chapman, Dr. Asa Gray, Mr. Austin, Professor Britton, and Dr. Morong. The various collections are now all arranged in a single series, but each sheet is identified by a designative label or stamp. There are also extensive collections of fruits, seeds, woods, and material illustrating economic botany, placed in cases and drawers.

The portion of the university library classified under botany is shelved in the room containing the herbarium. It now contains 3,700 bound volumes and about 5,000 pamphlets and extracts. These numbers do not, however, represent the whole reference strength of the collection, for all general works, scientific journals and publications of general scientific societies are shelved in the main library. All the regularly published journals devoted to botany are received, and the sets of the most of them are complete.

GENERAL INDEX.

The more important classified entries will be found under the following heads: Diseases, Floras, Host Plants, Journals, Nomenclature, Personals, Reviews.

Names of synonyms are printed in *Italics;* names of new species, etc., in **bold face.**

A

A. A. A. S., Buffalo meeting, 312.
Academy of Science, Indiana, 100; Iowa, 99; Ohio, 100.
Acanthochiton, 356; Wrightii, 356.
Acer, seedlings of, 212.
Acrostichum conforme, 253; pilosum, 253; **Pringlei,** 253; spathulatum, 254.
Aegilops *aromatica,* 364.
Africa, cedars of, 182; new plants from, 248.
Agrostis *brevifolia,* 14, 155.
Algæ, aqueous media for preserving, 140; calcareous, 215; cystocarp of Champia parvula, 109; development of Nemalion, 340.
Alisma Plantago, embryo-sac of, 123.
Alnus glutinosa, 12.
Alps, flora of, 381.
Alternanthera *flavescens,* 354; *latifolia,* 352; *Richardii,* 353.
Alternation of generations, 183.
Amaranthaceæ, synopsis of N. Am., 348.
Amber-tree in America, 311.
Amorpha, accessory buds of, 167.
Ampelopsis, accessory buds of, 167.
Androcryphia *longisela,* 68, 69.
Andropogon *alopecuroides,* 16, 156.
Anther, of Loranthaceæ, 181.
Anthoceros *jungermannioides,* 67.
Apluda *Zeugites,* 136.
Apodachlya, 325; brachynema, 325; pirifera, 325.
Apospory, in Scolopendrium, 42.
Apple, monograph of, 381.
Araiospora, 317, 323, 326; **pulchra,** 328.
Arenaria patula, 118.
Argemone, 44.
Aristida, protection against insects, 98.
Ascomycetes, sex-reproduction in, 250.
Aspergillus niger, 161.
Aspidium aculeatum, 254; athyrioides, 254; *chaerophylloides,* 255; filix-mas parallelogrammum, 255; juglandifolium, 255; *parallelogrammum,* 255; patulum chaerophylloides, 255; **scabriusculum,** 255; **strigillosum,** 256.
Asplenium chihuahuaense, 264; cicutarium, 257; cicutarium *paleaceum,* 258; *dubiosum,* 264; **Eatoni,** 258; erectum proliferum, 257; **fibrillosum,** 257; fragrans, 258; hastatum, 258; monanthemum, 258; serra, 259.
Assimilation, effect of salt of soil, 30; role of stomata, 29.
Aster *abbreviatus,* 277; *acuminatus,* 277; *Cornuti,* 277; Novi-Belgii, 97; *pallens,* 277; *patulus,* 275; *præcox,* 277; **puniceus × tardiflorus lancifolius,** 278; tardiflorus, 97, 275, 276, 374; tardiflorus **lancifolius,** 277; *Tradescanti,* 277; *vimineus,* 277.
Asterina dillitescens, 226; pelliculosa, 228.
Atheropogon *stolonifer,* 139.
Athyrium *sphærocarpum,* 254.
Atriplex arenarium, seedlings of, 212.
Avena **Mortoniana,** 133.

B

Bacteria, 243.
Bacterium Dianthi, 379.
Bambosulus *latifolius,* 157.
Baseonema, 248.
Batrachospermum, fertilization of, 231.
Beans, mimicry of pebbles, 235.
Bebb, M. S., bibliography of, 65; biographical sketch of, 53.
Betula, chalazogamy in, 44; seedlings of lutea, 211.
Bibliography, of American botany, 238.
Blastocladia, 45; Pringsheimii, 45, 51; **ramosa,** 50.
Boehmeria, fiber from, 98.
Botanical Club, of Vermont, 380.
Botanical Society of America, 313.
Buda marina, seedlings of, 211.
Buds, accessory, 166.

C

Cactaceæ, Coulter's revision, 242; mescal buttons, 314.
Calcium, role of, 249, 383.
Camassia Fraseri, and insects, 266.
Camphor water, for preserving algæ, 143.
Campulosus *aromaticus,* 364; *brachystachyus,* 363; *chapadensis,* 362; *cirrhosus,* 362; *planifolius,* 364.
Carbon dioxide, and protoplasm, 290.
Carex albicans, 7; **Arkansana,** 6; branching of, 312; of Check-List, 1; **Congdoni,** 6; **Eggertii,** 6; Emmonsii *elliptica,* 7; festiva *gracilis,* 5; feta **multa,** 8; grandis **Hellerl,** 7; **Hassei,** 5; **Idahoa,** 5; *Jamesii,* 8; microglochin, 4; **multimoda,** 5, Nebraskensis **ultriformis,** 8; *Peckii,* 7; **prasina × crinita,** 8; quadrifida **caeca,** 8; rosea *Arkansana,* 6; *Sartwelliana,* 6; **scabrata × crinita,** 8; subfusca, 5; varia, 7; Yosemitana, 6.
Cassia multipinnata, 234.
Casuarina, embryo-sac of, 374.
Ceanothus ovatus, 118.
Cell, disorganization of, 293.
Cellulose, reserve in seeds, 309.
Celosia, 355; floribunda, 356; Palmeri, 356; paniculata, 355.
Celtis occidentalis, 120.
Centrospheres, 184; in Alisma, 125.

Cercis, accessory buds, 167.
Chalazogamy, 44, 251, 337.
Champia parvula, development of cystocarp, 109.
Cheilanthes aurantiaca, 259; *ochracea*, 259.
Chichi, 44.
Chrome alum, for preserving algæ, 141.
Chrysophlyctis endobiotica, 247.
Citrous fruits, diseases of, 376.
Clusius, Carolus, 315.
Clypeum, 311.
Columbine Association, 312.
Coniferæ, root-hairs of, 372.
Cryptostachys *vaginata*, 15, 155.
Ctenium *Americanum*, 364; brachystachyum, 363; **brevispicatum**, 363; Carolinianum, 364; Chapadense, 362; cirrhosum, 362; **glandulosum**, 362; planifolium, 364; polystachyum, 361.
Cupressinoxylon Bibbinsii, 312.
Curvature, mechanics of, 160.
Cutinized membranes, and gases, 169.
Cyathea Schanschin, 259.
Cystocarp of Champia, 109.

D

Danthonia **Parryi**, 133.
Despretzia *Mexicana*, 136, 137.
Dicraurus, 354; alternifolius, 355; leptocladus, 355.
Diervilla trifida, accessory buds, 166.
Dimerosporium MacOwanianum, 228; psilostomatis, 228.
Dirca palustris, and insects, 73.
Diseases, of citrous fruits, 377; of potatoes, 247, 250; a root-fungus, 250; spot disease of orchids, 42; of sweet potatoes, 92; of tobacco, 311; translation of Tubeuf, 313.
Disorganization, phenomena of, 293.
Donaldsonia, 248.
Drosera rotundifolia, physiology of, 299.
Drosophyllum lusitanicum, nutrition of, 371.
Dryopteris *scabriuscula*, 256; *strigilosa*, 257.

E

Echinacea, angustifolia, 119.
Electricity and disorganization, 295.
Eleocharis melanocarpa, 122.
Embryo, 21; of Alisma, 129; of Sequoia, 332.
Embryo-sac, 182; of Alisma, 123; of Casuarina, 374; of Salix, 374; of Sequoia, 334, 336; of Taraxacum, 229.
Engelmann, Dr. George, 314.
Equisetum robustum, 122.
Erianthus *alopecuroides*, 16; compactus, 16; saccharoides, 16, 157.
Erythronium Americanum, polyembryony in, 97.
Ethno-botany, purpose of, 146.
Euphorbia, corollata and insects, 74; polygonifolia, seedlings of, 212.
Exobasidium Andromedæ, culture of, 101; *Azaleæ*, 102; Vaccinii, culture of, 101.

F

Ferns, of Jamaica, 42; of Mexico, 253.
Fertilization, 22; in Alisma, 126; in Batrachospermum, 231; in Champia, 109; in Sphaerotheca, 250.
Ficus elastica, 35; religiosa, 36.
Flora, of Chicago and vicinity, 118; lichens of Chicago, 309; lichens of Iowa, 43; of Metropolitan Parks district, 250; of states, comments on, 303; of West Virginia, 308.
Flowers and insects, 72, 266.
Forests, abrasion of, by snow and sleet, 248; of Transcaucasus, 312; of United States, 315.
Formalin, for preserving algæ, 143.
Fossombronia, 67; *angulosa*, 69, 70; cristata, 68, 69; cristula, 67, 69; *cubana*, 68, 70; Dumortieri, 68; foveolata, 67, 69; longiseta, 68, 69; Macouni, 68, 70; pusilla, 67, 70; salina, 70; Texana, 68, 69; Wrightii, 68, 70.
Fragaria **Helleri**, 36.
Fraxinus, seedlings of, 213.
Freezing device, 195.
Fruit, 21; diseases of citrous, 376.
Fungi, aquatic, new or peculiar, 45, 317; on citrous fruits, 376; Exobasidium, 101; Meliola, 224; new and critical, 311; parasitic, as index of hybrids, 98; phosphorescent, 381; a destructive root fungus, 250.

G

Gardens, Bartram, 43; Geneva, 313; Kew, 247; Missouri, 43; New York, 97, 182; Smith College, 43.
Gases, and cutinized membranes, 169.
Gentianaceæ, heterostyly in, 247.
Geothallus tuberosus, 9, 13.
Gillettia, 248.
Ginkgo, "chichi" on, 44.
Gleditschia, accessory buds, 167.
Gleichenia longissima, 259; pubescens, 259.
Gomphrena *latifolia*, 352; *vermicularis*, 348.
Gonapodya, 325; polymorpha, 325; siliquaeformis, 325.
Gramineæ, anatomical characters of, 357; Aristida, protection against insects, 98; Ctenium, synopsis of, 361; new species, 133; notes on, 155; Sporobolus, 14; terminology of floral organs, 18, 41; validity of Nash's changes, 16.
Greenland, collections from, 97.
Growth, mechanical hindrance of, 231; of banana leaves, 365.
Gymnogramme calomelanos, 259.
Gymnosperms, life history of Sequoia, 332; root-hairs of Coniferæ, 372.

H

Hamamelis Virginiana, seed propulsion, 170.
Heat, and disorganization, 294.
Helianthus annuus, 119.
Hepaticæ, Fossombronia, 67; Geothallus, 9; Plagiochila, 185; Underwood and Cook's exsiccatæ, 244.
Herbarium, Columbia College, 384; Deane's 210; Ellis's, 182; Redfield's, 181; U. S. National, 381.
Heterostyly, in Gentianaceæ, 247.
Heterotopic, 182.
Homalocenchrus lenticularis, 122.
Host plants, Andromeda, 101, 104; Arundinaria, 226; Bignonia, 227; Callicarpa, 226; Camellia, 227; citrous fruits, 376; Ficus, 35; Gonolobus, 227; Gordonia, 226; Ilex, 228; Laurus, 226; Oryza, 249; Persea, 226; Phoenix, 227; Rhododendron, 102; Rubus, 228; Sabal, 227; sweet potatoes, 92; Vaccinium, 104.
Hybrids, parasitic fungi as an index, 98.
Hymenophyllum axillare, 259; hirsutum, 259; lineare, 260; polyanthos, 260.

I

Index Kewensis, supplement, 43.
Insectivorous plants, Drosophyllum, 371.
Insects, and flowers, 72, 266; protection of Aristida against, 98.
Iresine, 348; *alternifolia*, 355; alternifolia *Texana*, 355; **arbuscula**, 350; canescens, 351; cassinaeformis, 351; *celosioides*, 353; **completa**, 349; *diffusa*, 354; elatior, 349; *flavescens*, 354; *gracilis*, 354; interrupta, 353; **Jaliscana**, 351; *laxa*, 352; latifolia, 352; **nigra**, 350; paniculata, 353; paniculata **Floridana**, 353; paniculata obtusifolia, 354; Pringlei, 352; Schaffneri, 352; vermicularis, 348.
Iris, and insects, 79; versicolor, and insects, 80.
Isoetes riparia, 218; saccharata, 218.
Isopyrum, root-tubers of, 250, 280.
Ixophorus, 18, 158; *unisetus*, 158.

J

Journals, Acta Hort. Petrop., 382; Am. Jour. Sci., 312; Amer. Nat., 382; Anat. Anz., 183; Ann. Bot., 42, 97, 183, 230, 231, 248, 249, 383; Arch. Neerl. Sci., 181; Arch. Sci. Phys. et Nat., 181; Ber. Deutsch. Bot. Gesell., 181, 247, 250; Book Reviews, 381; Bot. Central., 181, 251; Bot. Notiser, 98; Bot. Sem. of Neb., 177, 307; Bot. Zeit., 248; Bull. Agric. Exp. St., 99, 248, 251; Bull. Bot. Dept. Jamaica, 42, 380; Bull. Lab. Nat. Hist. State Univ. Iowa, 43; Bull. l'Herb. Boiss., 182, 311, 312, 313; Bull. Soc. Bot. France, 181, 182; Bull. Torr. Bot. Club, 181, 382; Bull. U. S. Dept. Agric., 248; Can. Rec. Sci., 177; Central. f. Bak., 181; Commercial Trav. Home Mag., 247; Die natuerlich. Pflanz., 184, 311; Dry Goods Bull., 98; Erythea, 42; Garden and Forest, 42, 247, 311; Gard. Chron., 182, 380, 381; Hedwigia, 308; Jour. Bot., 43, 44, 248, 311, 382; Kew Bull., 43, 250; Le Botaniste, 184; Linn. Fern Bull., 247; Malpighia, 181; Micr. Bull., 182; Minn. Bot. Studies, 171, 177, 250; New Eng. Mag., 314; Pharmaceut. Rev., 98; Pittonia, 313, 380; Proc. Philad. Acad., 97, 249; Rev. Mycol., 248; Science, 97, 248, 311; Therap. Gaz., 314; Tokyo Bot. Mag., 44, 249.
Juglans, accessory buds, 168; regia, chalazogamy in, 251.

K

Karyokinesis, 249.
Kerner's "Nat. Hist. of Plants," 20, 37.
Krombholzia *latifolia*, 136; *Mexicana*, 136.

L

Lactuca Scariola, distrib. in U. S., 34.
Langloisia, 313.
Lasiodiplodia tubericola, 92.
Lastrea *scabriuscula*, 256; *strigilosa*, 257.
Lathyrus maritimus, seedlings of, 211.
Lawson, Geo., death, 42.
Leaves, banana, growth of, 365; nyctitropic position of, 181; parallel-veined, 181.
Leguminosæ, accessory buds, 166.
Leptomitaceæ, 325.
Leptomitus, 325; lacteus, 325.
Leptostromella elastica, 35.
Library, Lloyd's, 97.
Lichens, of Chicago, 309; of Iowa, 43; N. Am. species of Parmelia, 202; the only "thallophytes," 237.
Light, and disorganization, 295.
Limnanthemum nymphoides, 234.
Lippia iodantha, 247.
Lithophila, 348.
Lomaria attenuata, 260; capensis, 260; procera, 260.
Lonicera, accessory buds, 166.
Lophophora, mescal buttons, 314.
Loranthaceæ, anthers of, 181.
Lycopodium alpinum sabinaefolium, 42.

M

Marattia laxa, 260.
Melanthium virginicum, and insects, 273.
Meliola, 224; amphitricha, 226; bidentata, 227; Camelliæ, 227; Cookeana, 226; cryptocarpa, 226; furcata, 227; heteromeles, 227; inermis, 228; MacOwaniana, 228; manca, 228; Martiniana, 226; palmicola, 227; Penzigi, 228; psilostomæ, 228; quinquespora, 228; sanguinea, 228; tenuis, 225.
Mescal buttons, 314.
Microscopieal journals, articles in, 178.
Mimicry, of fungi by insects, 41, 248; of pebbles by beans, 235.
Mosses, Cardot's, 381; Kindberg's, 308.
Mueller, Jean, 247, 313.
Muhlenbergia *aspericaulis*, 15.
Museums, 307.
Mycorhiza, of Coniferæ, 373.
Myosotis laxa, 120.
Myriophyllum Farwellii, 97; scabratum, 97.

N

Necrology, George Lawson, 42; Jean Mueller, 247.
Nemalion multifidum, development of, 340.
Nephrodium *Mexicanum*, 255; *scabriusculum*, 256; *sphærocarpum*, 254; *strigilosum*, 257.
New England botanists, 314.
New Zealand, botany of, 182; destructive fungus of, 250.
Nomenclature, binary name, 179, 246; of Carex species, 1; dates and references, 90; double citation, 1; general comments, 85, 88; inconsistencies, 82; priority, 90; suppressed names, 4; varietal names, 3.
Notholaena Hookeri, 260.
Nothoscordum *ornithogaloides*, 266; striatum, and insects, 266.
Nucleolus, 181, 183, 249.
Nuttall's Compositæ, dates of, 42.

O

Ocimum *frutescens*, 234.
Oil, of cinnamon, 308; of citron, 308.
Ombrophilous foliage, 163.
Onoclea, experiments with, 382.
Ophioglossaceæ, Bower's studies in, 249.
Orchids, spot disease of, 42.
Organic foods, selection of, 161.
Oryza sativa, anatomical characters of, 357.

P

Paleohillia, a fossil plant, 207.
Panicum boreale, 18, 157; capillare, 158; dichotomum, 18, 158; divaricatum, 17, 157; flexile, 158; latifolium, 17, 157; laxiflorum, 18, 158; minus, 17; Porterianum, 17.
Parmelia, 202; acetabulum, 206; Borreri, 205; cetrata, 203; compacta, 204; congruens, 205; conspersa, 205; crinita, 203; hypotropa, 204; hypotropoides, 204; isidiocera, 206; Kamtschadalis, 205; molliuscula, 205; perlata, 203; praesignis, 205; saccatiloba, 204; sphærosporella, 206; submarginalis, 204; tiliacea, 205; tinctorum, 204.
Pellaea cordata, 261; HYMENOLOMA, a new section, 261; **membranacea**, 262; Pringlei, 262; *sagittata*, 261.
Penicillium glaucum, 161.
Perrilla frutescens, 234; *ocimoides*, 234.
Personals, Arthur, 380; Bailey (L. H.), 381, 383; Bailey (W. W.), 380; Baker, 182; Barnes, 380; Beal, 311; Bennett (A. W.), 381; Bray, 380. Britton (N. L.), 380, 383; Cheney, 247; Clusius, 315; Cockerell, 380; Cook, 247; Coulter (J. M.), 183; Crozier, 311; Curtis (C. C.), 383; Deane, 250; Eaton, 42; Engelmann, 314; Halsted, 381; Harper, 248; Harshberger, 381; Heller, 42; Istvanffi, 315; Kedzie, 311; Lagerheim, 42; Lloyd, 381; MacDougal, 248, 347, 380; Macfarlane, 381; Mueller (J.), 313; Oudemans, 247; Peirce, 248; Pennock, 182; Prentiss, 183; Robinson (B. L.), 381; Sargent (F. L.), 312; Schiffner, 380; Shaw, 384; Stokes, 312; True, 247; Underwood, 380; Ward (Marshall), 43; Wilson (W. P.), 381.
Phacelia Covillei, 233.
Phaseolus **smilacifolius**, 233.
Phegopteris rudis, 263.
Philoxerus, 348; *vermicularis*, 348.
Phosphorescent fungi, 381.
Phytophthora Cactorum, 311; Nicotianæ, 311.
Pigment, of negro skin, 97.
Pinus, rate of growth, 311; Torreyi, 312; twisting of grain, 159.
Plagiochila, 185; asplenioides, 187; **Columbiana**, 189; **Floridana**, 190; interrupta, 187; Ludoviciana, 192; *macrostoma*, 187; *nodosa*, 187; *porelloides*, 187; *spinulosa*, 191; **Sullivantii**, 191; nudata, 193; Virginica, 190.
Pollen-tube, of Sequoia, 337.
Pollination, 24, 72, 266.
Polembryony, in Erythronium, 97.
Polygonatum, and insects, 268; *biflorum commutatum*, 268; giganteum, and insects, 268.
Polygonum hydropiperoides, and insects, 72; Pennsylvanicum, and insects, 72; seedlings of, 211.
Polypodium angustifolium, 263; angustum, 263; fallax, 263; fraternum, 263; loriceum, 263; Martensii, 263; moniliforme, 263; plectolepis, 263; repens, 263; reptans, 263; squamatum, 264.
Poplars of N. Am., 251.
Potamogeton, diversifolius, 121; *hybridus*, 121; interruptus, 121.
Prentiss, A. N., biographical sketch of, 283.
Pringleochloa stolonifera, 137.
Protoplasm, and carbon dioxide, 290.
Prunus serotina, accessory buds, 166.
Pteris *lutea*, 259; podophylla, 264; *sagittata*, 261.
Puccinia dispersa, 99.

R

Ramie, 98.
Reproduction, criticism of Kerner, 20.
Reviews, Arthur and Bolley's "Bacteriosis of carnations," 378; (L. H.) Bailey's "Plant breeding," 175; (W. W.) Bailey's "R. I. flowers," 90; Bergen's "Elements," 173; Bessey's "Essentials," 375; Calkins's "Lichens of Chicago," 309; Campbell's "Mosses and Ferns," 93; Contr. Nat. Herb., 38, 39, 176, 242; Cooley's "Reserve cellulose," 309; Corren's "Physiol. of Drosera," 299; "Physiol. of tendrils," 298; Coulter's "Cactaceæ," 242; Cratty's "Aquat. phanerogams," 95; Davis's "Batrachospermum," 231; Dean's "Vegetable culture," 378; Donnell-Smith's "Enumeration of Guat. plants," 40; Dœrfler's "Adressbuch," 306; Gregory's "Plant anat.," 239; Just's "Bot. Jahresb.," 95; Kerner's "Nat. Hist. of Plants," 20, 37; King's "Soil," 94; Klemm's "Cell disorganization," 293; Laurie's "Food of plants," 378; Lopriore's "Protoplasm and CO_2," 292; McBride's "Lessons," 173; McClatchie's "Fl. of Pasadena," 308; Migula's "Bacteria," 243; Millspaugh and Nuttall's "Fl. W. Va.," 308; Penhallow's "Outlines of classif." 307; Pettit's "Cultures of fungi," 39; Rusby and Jelliffe's "Bot. for pharmacists," 240; Saccardo's "Ital. bibl.," 96; Sedgwick and Wilson's "Gen. Biol., 176; Swingle and Webber's "Citrous fruits," 376.
Rhamnus Frangula, 235.
Rhipidium, 317, 325; **Americanum**, 320, 327; continuum, 318; elongatum, 318; interruptum, 318; spinosum, 319.
Rhus Toxicodendron, acid of, 97.
Root-hairs, of Coniferæ, 372.
Roots, contractile, 181.
Rosa **Macdougali**, 36.
Rosea *elatior*, 350.
Rosellinia radiciperda, 250.

S

Saccharomyces farciminosus, 181.
Salix, and insects, 75; cordata, and insects, 76; herbacea, and insects, 75; humilis, and insects, 77.
Sapromyces, 317, 322, 326; **androgynus**, 329; elongatus, 326; Reinschii, 323.
Saxifragaceæ, two new genera, 181.
Scirpus Torreyi, 122.
Scitamineæ, seeds of, 249.
Scolopendrium, apospory in, 42.
Seeds, dissem. in Hamamelis, 170; latent life, 181; reserve cellulose, 309; of Scitamineæ, 249.
Seedlings, collection of, 210.
Selaginella, ligule of, 248.
Selective power of fungi, 161.
Sequoia sempervirens, life-history of, 332.
Setaria, 158; *uniseta*, 158.
Sibara, 313.
Sium cicutaefolium, seedlings of, 214.
Smilacina racemosa, and insects, 270; stellata, and insects, 269.
Solidago, poisoning by, 42; sempervirens, seedlings of, 212.

Spathularia *crispata*, 311.
Spiraea sorbifolia, accessory buds, 166.
Sporobolus aspericaulis, 15; *brevifolius*, 14, 15; cuspidatus, 14; *neglectus*, 15, 156; *vaginaeflorus*, 15; vaginatus, 15.
Sprague ola Americana, 311.
Starch, conversion to sugar, 249.
Stomata, in assimilation, 29; in transpiration, 27.
Sugar, conversion from starch, 249.
Summer schools, Stanford Univ., 383; Univ. of Penn., 381; Univ. of Wis., 380.

T

Taraxacum, embryo-sac of, 229.
Tendrils, physiology of, 298; temperature irritability of, 248.
Thaspium barbinode, 119; pinnatifidum, 118.
Tilletia horrida, 249; oryzæ, 249.
Tradescantia micrantha, 301.
Transpiration, experiments, 26; regulation by guard-cells, 28; stomatic and cuticular, 27.
Trichomanes radicans, 264.
Trillium, and insects, 271; recurvatum, and insects, 273; sessile, and insects, 272.
Tromsdorfia, 348; *canescens*, 351.
Tubers of Isopyrum, 250, 280.

U

Umbelliferæ, substance of oil-tubes, 181.
Uncinia, 4.
University of Chicago, botany at, 183.
Urochloa uniseta, 18, 158.
Ustilago virens, 249.
Uvularia, and insects, 270; grandiflora, and insects, 270.

V

Vagnera *racemosa*, 270; *stellata*, 269.
Villa *cuspidata*, 14, 15, 155; *gracilis*, 14; *Richardsonis*, 15, 155; vaginaeflora, 155.
Viola, synonymy of pedata, 380.
Vitaceæ, accessory buds, 168.
Vitis, accessory buds, 168.
Vittaria lineata, 264.

W

Widdringtonia, 182.

X

Xanthium, seedlings of, 212.

Y

Yeast, pathogenic, 181.
Yucca *baccata*, 311; mohavensis, 311.

Z

Zeugites, 136; Americana, 136; colorata, 137; Galeottiana, 136; Hartwegi, 136; latifolia, 136; Mexicana, 137; **smilacifolia**, 134, 137.

INDEX TO AUTHORS.

Atkinson, G. F., 283.

Bailey, L. H., 1, 246.
Barnes, C. R., 293.
Bray, W. L., 348.

Campbell, D. H., 9.
Chamberlain, Chas., 229, 374.
Cheney, L. S., 159.
Chester, Grace D., 340.
Clendenin, Ida, 92.
Coulter, J. M., 231.

Davenport, G. E., 85, 253.
Davis, B. M., 109.
Day, R. N., 169.
Deane, Walter, 53, 210.
Dewey, L. H., 34.

Earle, F. S., 224.
Evans, A. W., 185.

Fernald, M. L., 275, 374.

Greene, E. L., 179.
Grout, A. J., 97.

Harshberger, J. W., 146.
Hill, E. J., 118.
Holm, Theo., 98, 163, 207, 357.
Holzinger, J. M., 36.

Knowlton, F. H., 82.
Kuntze, Otto, 88.

MacDougal, D. T., 160, 280.
MacMillan, C., 20.
Maxwell, W., 365.
Meehan, Thos., 90.
Morgan, A. P., 237.

Nash, G. V., 41, 155.

Osterhout, W. J. V., 140, 195.

Palmer, T. C., 218.
Penhallow, D. P., 215.
Pollard, C. L., 233.
Putnam, Bessie L., 170.

R. — —, 41, 290, 372.
Richards, H. M., 101.
Robertson, Chas., 72, 266.
Rose, J. N., 301.
Rowlee, W. W., 178.
Russell, H. L., 243.

Schaffner, J. H., 123.
Scribner, F. L., 14, 133.
Setchell, W. A., 140.
Shaw, W. R., 332.
Sherzer, W. H., 235.
Shull, G. H., 166.
Smith, J. G., 16, 361.
Smith, R. E., 35.

Thaxter, Roland, 45, 317.
True, R. H., 161, 230, 298, 299, 371.

Uline, E. B., 348.
Underwood, L. M., 67.

Willey, Henry, 202.
Woods, A. F., 26.